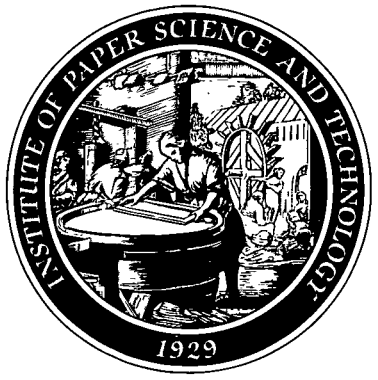


Institute of Paper Science and Technology

EFFECT OF AGING TIME ON PROPERTIES OF TREATED AND UNTREATED PAPERS

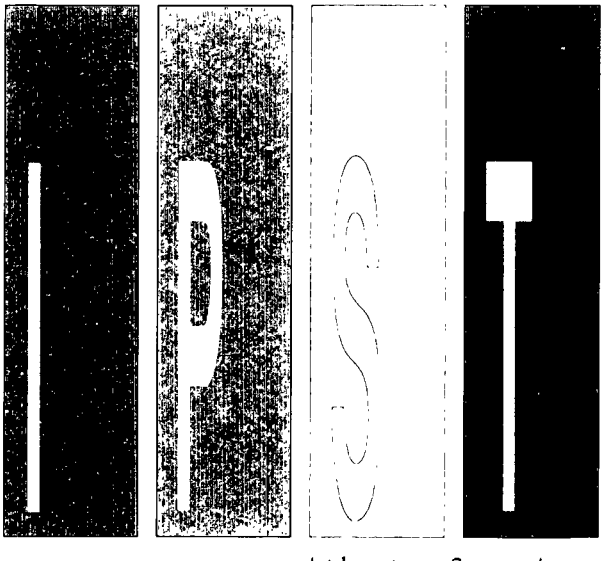
Project 3875

Summary Report

to

THE LIBRARY OF CONGRESS

April 4, 1994



Atlanta, Georgia

INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY
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- to provide high quality students with a multidisciplinary graduate educational experience which is of the highest standard of excellence recognized by the national academic community and which enables them to perform to their maximum potential in a society with a technological base; and
- to sustain an international position of leadership in dynamic scientific research which is participated in by both students and faculty and which is focused on areas of significance to the pulp and paper industry; and
- to contribute to the economic and technical well-being of the nation through innovative educational, informational, and technical services.

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THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Atlanta, Georgia

EFFECT OF AGING TIME ON PROPERTIES OF TREATED AND UNTREATED PAPERS

IPST Project 3875

A Summary Report

to

THE LIBRARY OF CONGRESS

April 4, 1994

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INTRODUCTION

Four grades of treated and untreated papers were subjected to accelerated aging by the Library of Congress. Aging periods were 0, 3, 6, 10, 13, 17, 24, and 30 days.

The samples were then tested at the Institute of Paper Science and Technology for MIT folding endurance, tensile strength, stretch, tensile energy absorption, tensile stiffness, zero-span tensile strength, internal tear resistance, cold extract pH, alkaline reserve, hot alkali solubility, viscosity, brightness, opacity, and L a b color.

The individual test results for each aging period are given in Progress Reports One through Eight. This Summary Report includes averages and standard deviations for each property and aging period, plots of each property versus aging time, and calculated degradation rates.

SAMPLES

Samples submitted by the Library were identified as:

ARC-3	CSC-3	NPC-3	ASC-3
ART-3	CST-3	NPT-3	AST-3

In the samples codes, the first two letters identify the grade of paper,

(AR = alum rosin sized paper CS = Clear Spring Offset)

(NP = newsprint AS = alkaline sized paper)

the third letter indicates either a Control or Treated sample, and the number is the days of accelerated aging.

TEST PROCEDURES

The procedure used for performing each of the test types was:

1. MIT fold endurance (TAPPI T511 tested with 1 kg tension)*
2. Tensile properties (TAPPI T494)
3. Zero-span tensile (TAPPI T231)
4. Internal tear resistance (TAPPI T414)
5. Cold extract pH (TAPPI T509)
6. Alkaline reserve (ASTM D4988)
7. Hot alkali solubility (TAPPI T212)
8. Viscosity (TAPPI T230)
9. Brightness (TAPPI T452)
10. Opacity (TAPPI T425)
11. L, a, b color (TAPPI T524)

* An addendum to this report will be published reporting folding endurance results for tests made with 1/2 kg tension.

TEST RESULTS

The averages and standard deviations for each test type are given in Tables I through XXIII, and plots of each test type versus aging time is shown in Figs. 1 through 23. Calculated regression lines for the control and treated samples are shown in each figure. Statistics for the regression lines, including the coefficient (degradation rate) are given in each Table.

Folding endurance values in Tables I and II are reported as the number of double folds. Plots of these data are not linearly related to aging time. Hence, the plots (Figs. 1-AR, 1-CS, 1-NP, 1-AS, 2-AR, 2-CS, 2-NP, and 2-AS) show aging time plotted against log fold. The regression statistics in Tables I and II are also based on log fold.

The regression lines for the alkaline reserve data (Fig. 21) suggest a gradual increase for the treated samples. However, there is sufficient noise in the repeatability to conclude that there is no difference in alkaline reserve between the beginning and end of the aging time.

The viscosity results suggest a gradual non-linear decrease in viscosity of the pulps of both treated and control samples. This is troublesome even though the treated samples appear to equilibrate at a higher viscosity. Viscosity is, by the nature of the measurement, confounded under the best of circumstances. We recommend that a small set of samples be analyzed over time to determine if there is a decrease in the average cellulose or hemicellulose polymer chain length, as the viscosity decreases.

TABLE I

MD MIT FOLD DATA (double folds)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	129.7	92.6	107.1	120.3	89.1	72.5	42.9	38.3
	Std Dev	39.5	22.7	14.0	24.9	33.1	25.6	4.0	6.8
3	Average	60.8	55.8	74.0	79.1	74.3	84.2	28.6	37.3
	Std Dev	21.7	17.8	8.9	11.5	27.9	16.7	4.6	5.8
6	Average	37.3	61.8	44.4	71.5	41.8	52.3	24.7	26.2
	Std Dev	10.1	12.9	8.9	11.3	11.4	12.4	4.8	5.9
10	Average	22.8	39.0	24.4	55.9	29.0	54.6	30.5	28.3
	Std Dev	7.0	6.3	4.0	8.6	11.5	19.1	2.9	3.6
13	Average	14.7	33.3	11.8	53.6	17.6	38.1	26.7	23.5
	Std Dev	4.9	7.8	2.6	9.6	6.6	17.3	4.8	3.7
17	Average	8.1	36.7	4.9	53.7	9.1	35.2	32.8	26.8
	Std Dev	2.6	13.0	1.0	7.5	4.1	17.7	4.0	3.7
24	Average	2.9	18.3	2.7	30.8	5.7	24.0	18.8	26.3
	Std Dev	0.7	3.6	0.7	7.0	1.9	12.0	1.8	3.3
30	Average	2.9	15.1	1.5	14.2	2.5	12.4	17.0	19.6
	Std Dev	0.7	4.2	0.5	3.9	0.8	7.9	2.3	3.0

REGRESSION STATISTICS

R Squared	0.961	0.941	0.978	0.924	0.989	0.944	0.647	0.691
Coefficient	-0.057	-0.025	-0.065	-0.026	-0.053	-0.025	-0.010	-0.008
Std Err	0.0047	0.0692	0.1100	0.0031	0.0022	0.0025	0.0030	0.0021
Constant	1.96	1.90	2.00	2.05	1.96	1.93	1.56	1.54

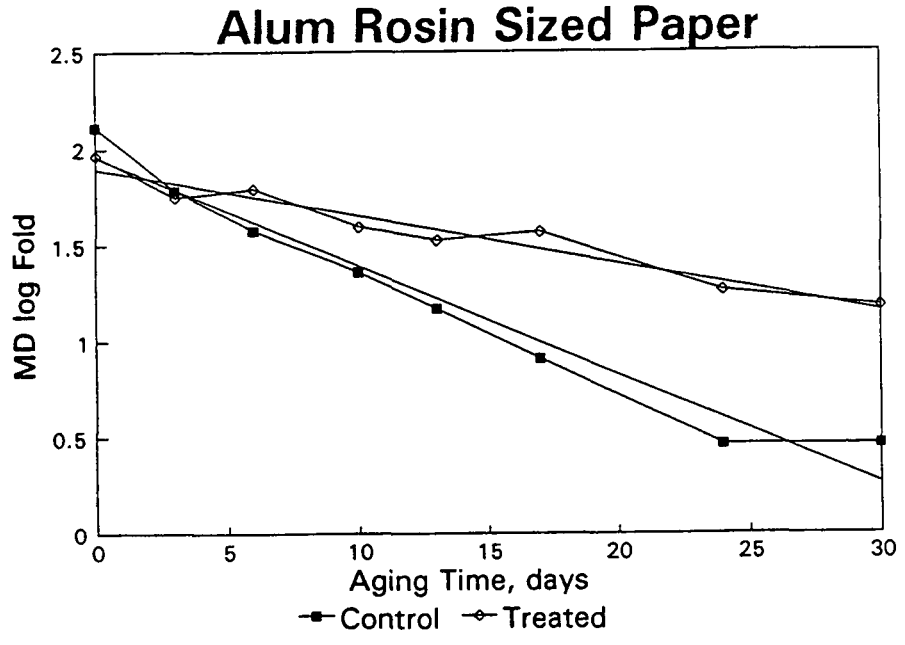

Fig. 1-AR Affect of Aging Time on log MD Folding Endurance.

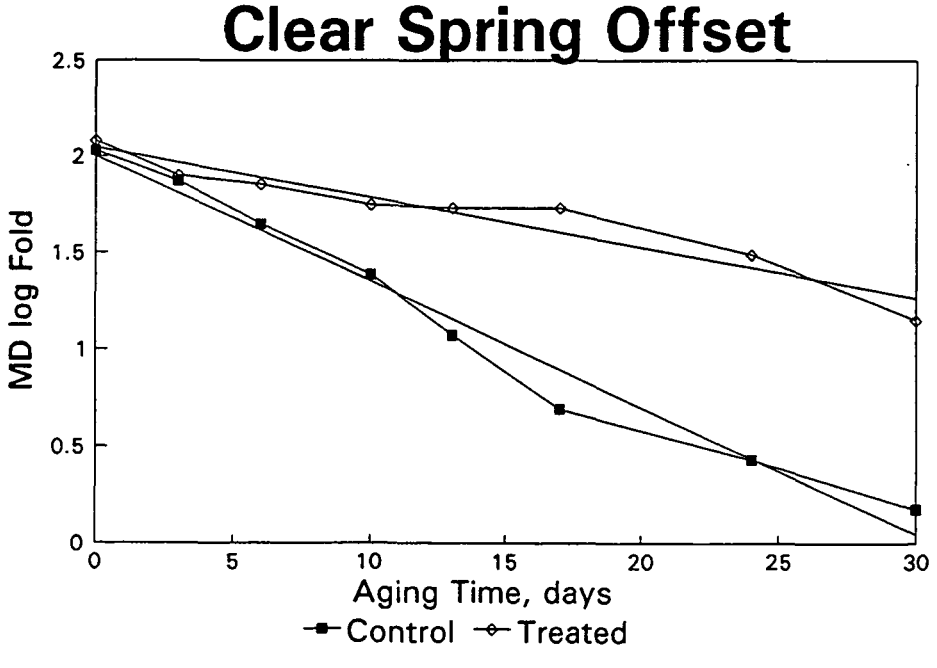

Fig. 1-CS Affect of Aging Time on log MD Folding Endurance.

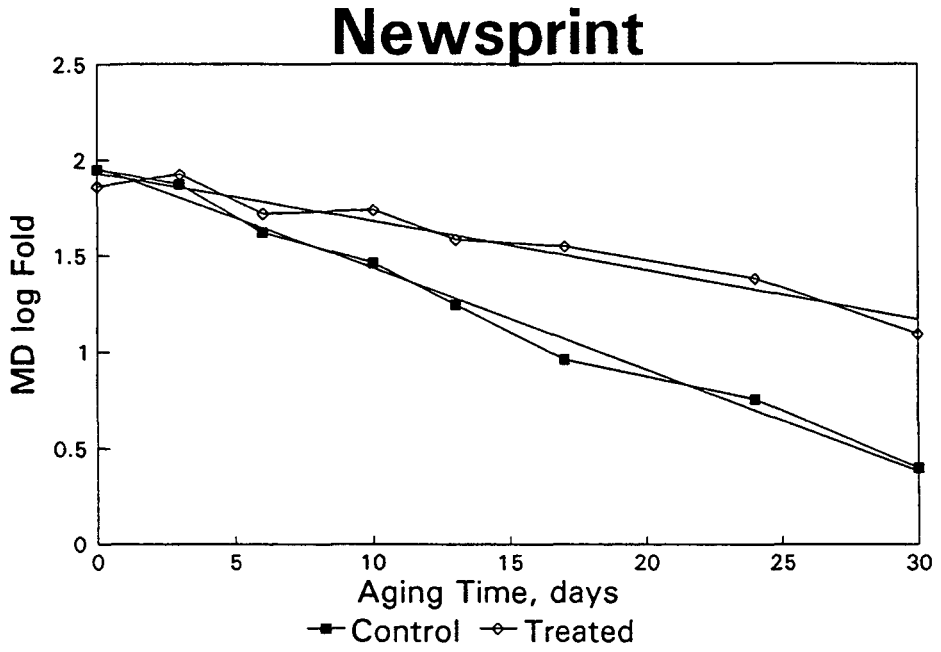

Fig. 1-NP Affect of Aging Time on log MD Folding Endurance.

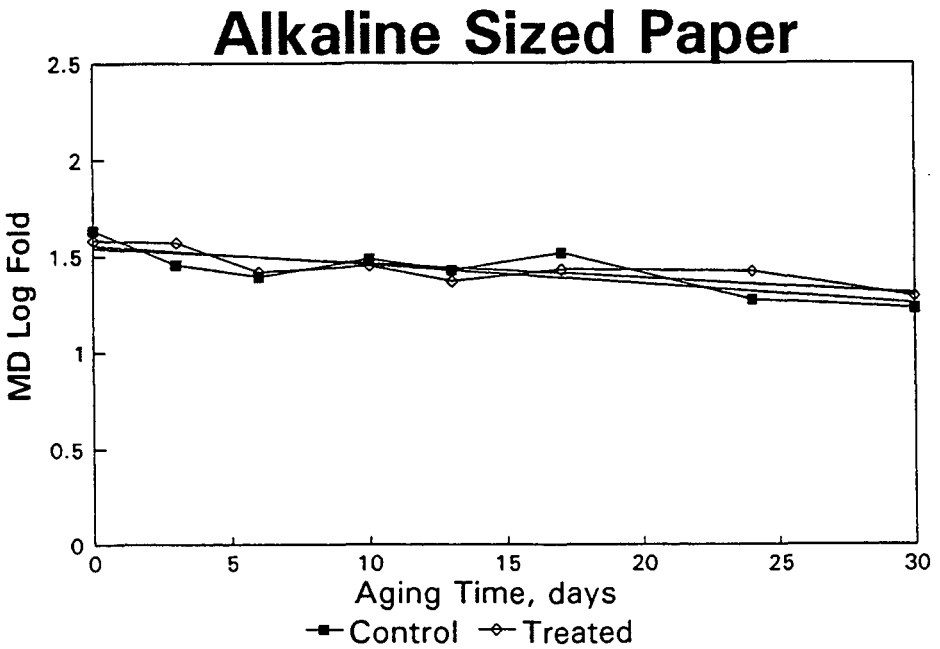

Fig. 1-AS Affect of Aging Time on log MD Folding Endurance.

TABLE II

CD MIT FOLD DATA (double folds)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	25.7	24.3	29.3	24.3	10.2	9.1	33.9	30.8
	Std Dev	6.2	4.7	5.5	4.1	4.2	3.1	3.6	4.1
3	Average	20.1	17.9	23.9	26.7	8.8	9.6	30.0	29.9
	Std Dev	4.0	2.3	2.2	2.5	2.3	3.0	3.0	5.4
6	Average	17.3	18.8	20.6	21.7	7.9	7.2	30.9	28.6
	Std Dev	3.5	2.3	4.5	3.7	2.2	1.9	7.1	3.7
10	Average	12.5	18.1	14.3	22.0	4.5	7.2	29.9	32.8
	Std Dev	4.9	5.9	1.6	3.4	1.0	1.5	4.0	3.6
13	Average	8.3	17.1	12.1	23.0	4.1	9.5	32.9	31.7
	Std Dev	2.0	3.0	2.3	3.5	0.7	2.6	6.9	4.4
17	Average	6.7	12.7	9.9	17.0	4.5	6.8	30.3	30.5
	Std Dev	0.8	2.7	1.2	3.0	1.8	1.7	3.9	4.5
24	Average	3.7	9.8	4.8	15.9	2.2	4.6	27.3	27.3
	Std Dev	0.9	1.5	1.3	3.1	0.6	0.8	2.7	3.4
30	Average	2.6	9.4	2.5	13.4	1.6	4.7	26.9	25.0
	Std Dev	0.7	2.5	1.4	2.8	1.1	0.8	3.4	3.4

REGRESSION STATISTICS

R Squared	0.994	0.923	0.985	0.886	0.959	0.747	0.634	0.462
Coefficient	-0.034	-0.014	-0.035	-0.009	-0.027	-0.011	-0.003	-0.003
Std Err	0.0011	0.0016	0.0018	0.0014	0.0023	0.0025	0.0008	0.0011
Constant	1.41	1.36	1.51	1.42	1.01	0.99	1.51	1.50

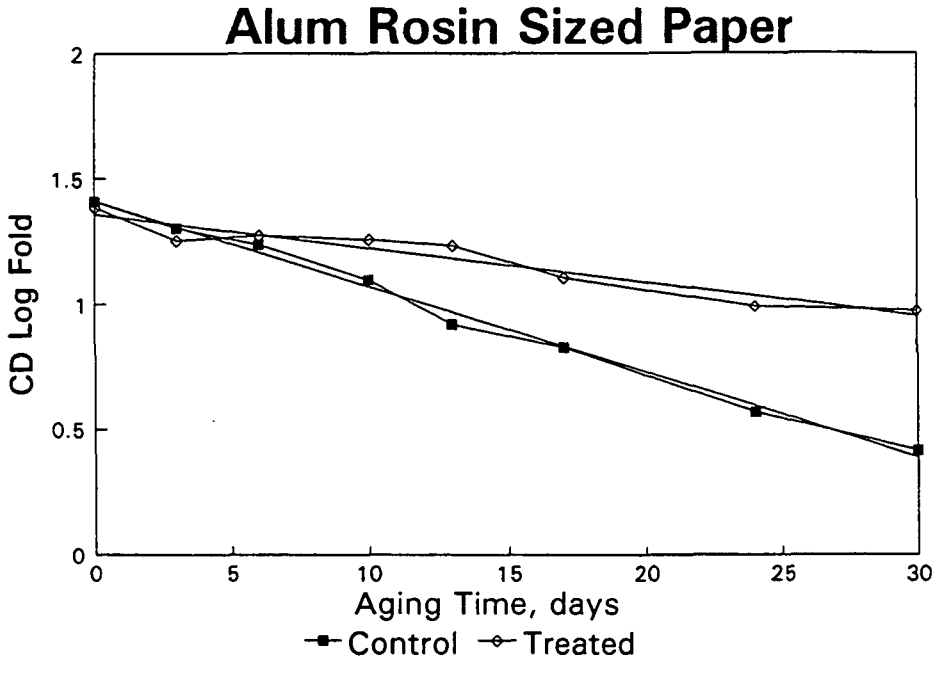

Fig. 2-AR Affect of Aging Time on log CD Folding Endurance.

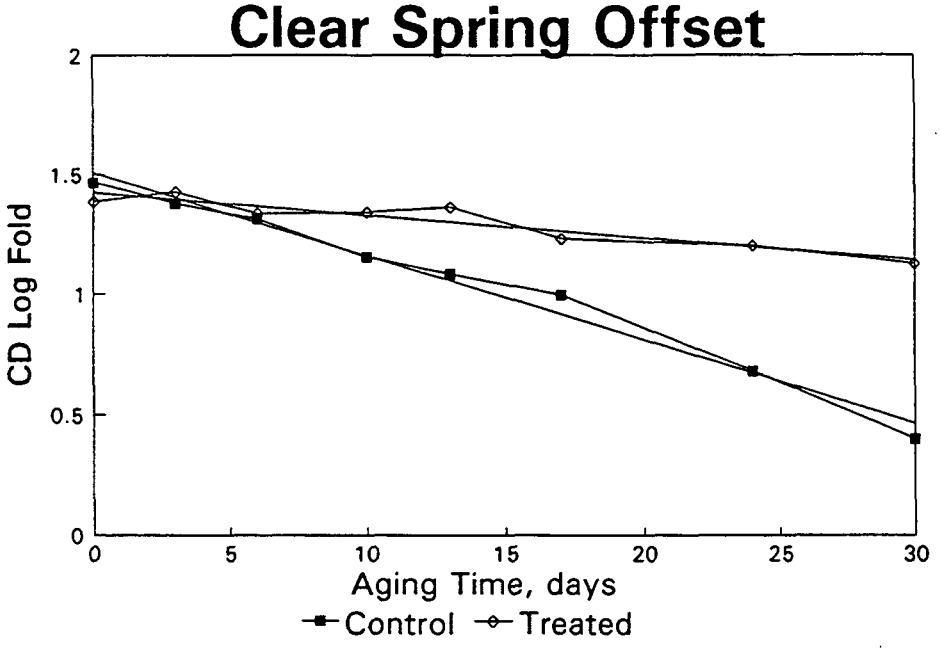

Fig. 2-CS Affect of Aging Time on log CD Folding Endurance.

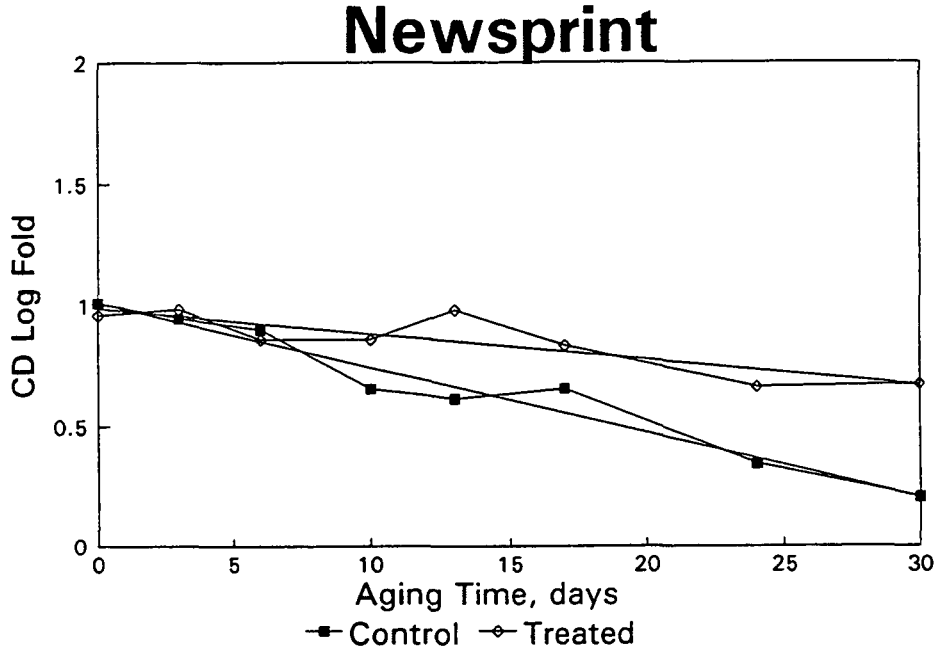

Fig. 2-NP Affect of Aging Time on log CD Folding Endurance.

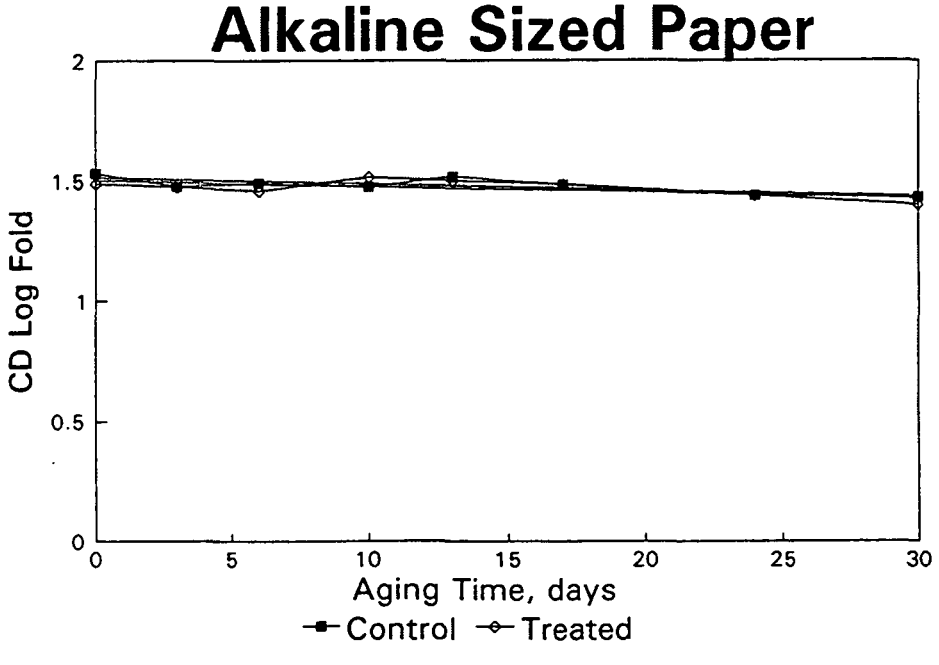

Fig. 2-AS Affect of Aging Time on log CD Folding Endurance.

TABLE III

MD TENSILE DATA (kN/m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	5.08	4.97	7.99	7.82	2.71	2.63	4.94	5.37
	Std Dev	0.25	0.41	0.13	0.23	0.13	0.14	0.64	0.11
3	Average	5.11	4.69	7.76	7.98	2.56	2.55	5.26	5.42
	Std Dev	0.26	0.30	0.42	0.26	0.29	0.18	0.19	0.09
6	Average	4.79	5.02	7.71	7.82	2.71	2.66	5.35	5.38
	Std Dev	0.37	0.32	0.15	0.31	0.14	0.12	0.19	0.19
10	Average	4.92	42.90	7.30	7.74	2.66	2.62	5.25	5.17
	Std Dev	0.25	7.18	0.20	0.33	0.15	0.17	0.19	0.08
13	Average	4.63	4.70	7.09	7.75	2.60	2.60	5.17	5.28
	Std Dev	0.22	0.15	0.31	0.27	0.17	0.18	0.21	0.12
17	Average	4.40	4.74	6.70	7.53	2.39	2.68	4.98	5.26
	Std Dev	0.29	0.29	0.34	0.22	0.14	0.19	0.17	0.13
24	Average	4.24	4.68	6.41	7.62	2.29	2.64	5.11	5.29
	Std Dev	0.25	0.46	0.22	0.37	0.11	0.29	0.23	0.12
30	Average	3.93	4.34	5.94	7.22	2.25	2.40	4.96	5.21
	Std Dev	0.20	0.33	0.59	0.27	0.15	0.32	0.12	0.14

REGRESSION STATISTICS

R Squared	0.948	0.641	0.989	0.805	0.823	0.233	0.157	0.414
Coefficient	-0.040	-0.016	-0.069	-0.020	-0.016	-0.004	-0.006	-0.005
Std Err	0.0038	0.0049	0.0029	0.0040	0.0031	0.0031	0.0056	0.0026
Constant	5.15	4.94	8.00	7.94	2.73	2.65	5.20	5.37

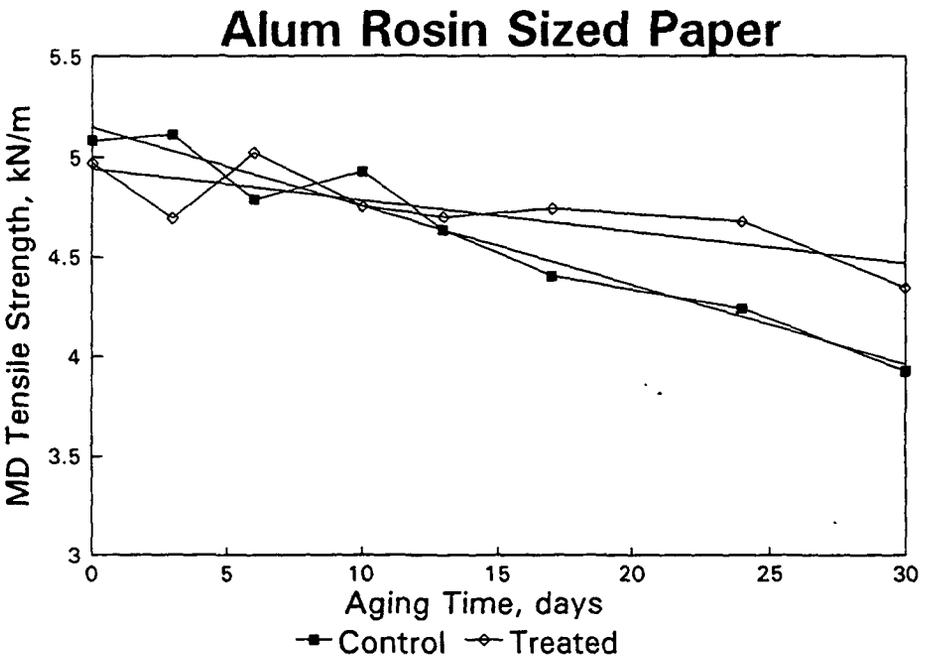

Fig. 3-AR Affect of Aging Time on MD Tensile Strength.

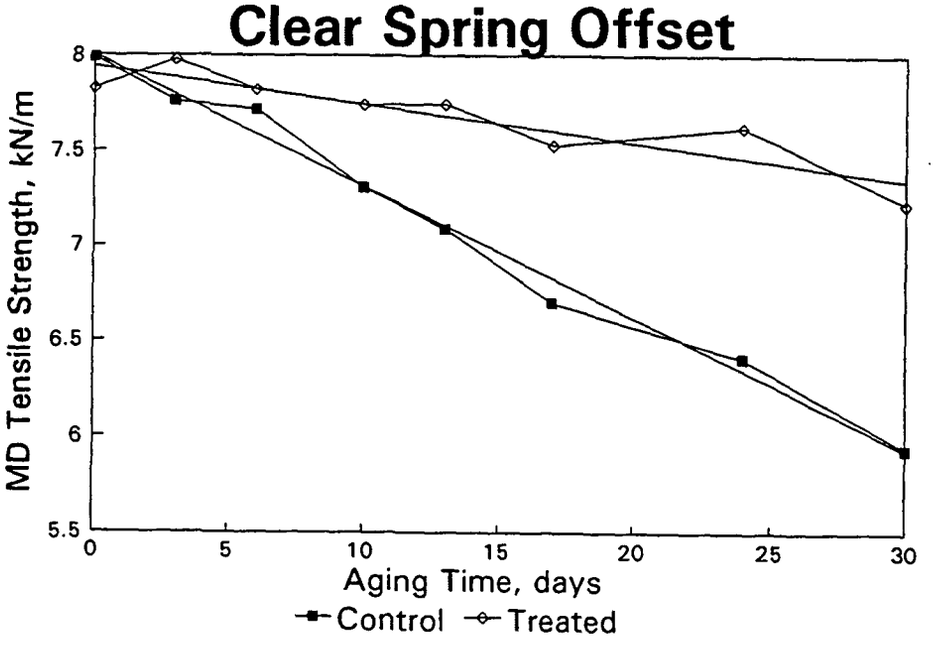

Fig. 3-CS Affect of Aging Time on MD Tensile Strength.

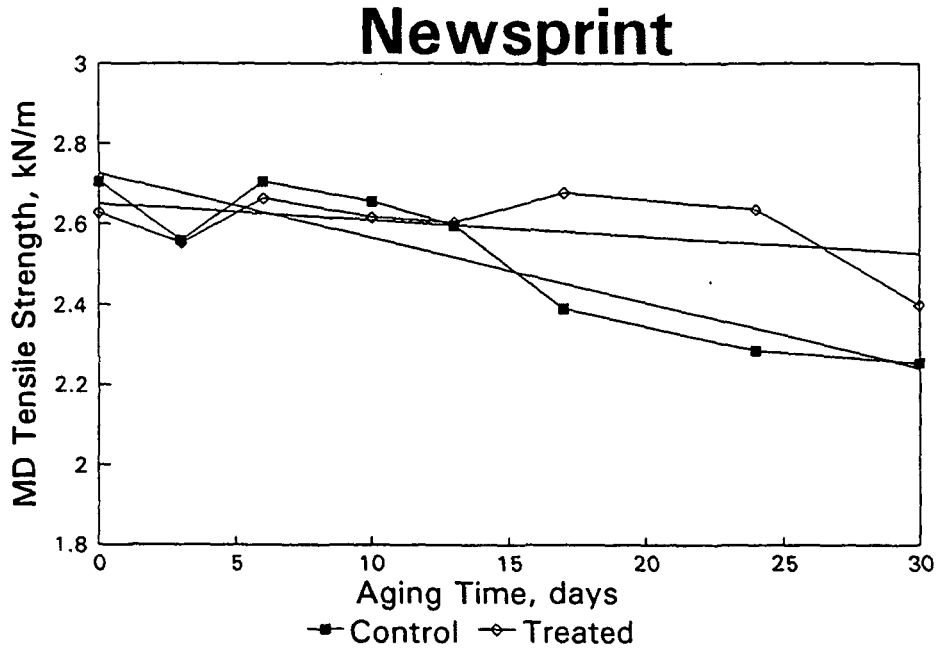

Fig. 3-NP Affect of Aging Time on MD Tensile Strength.

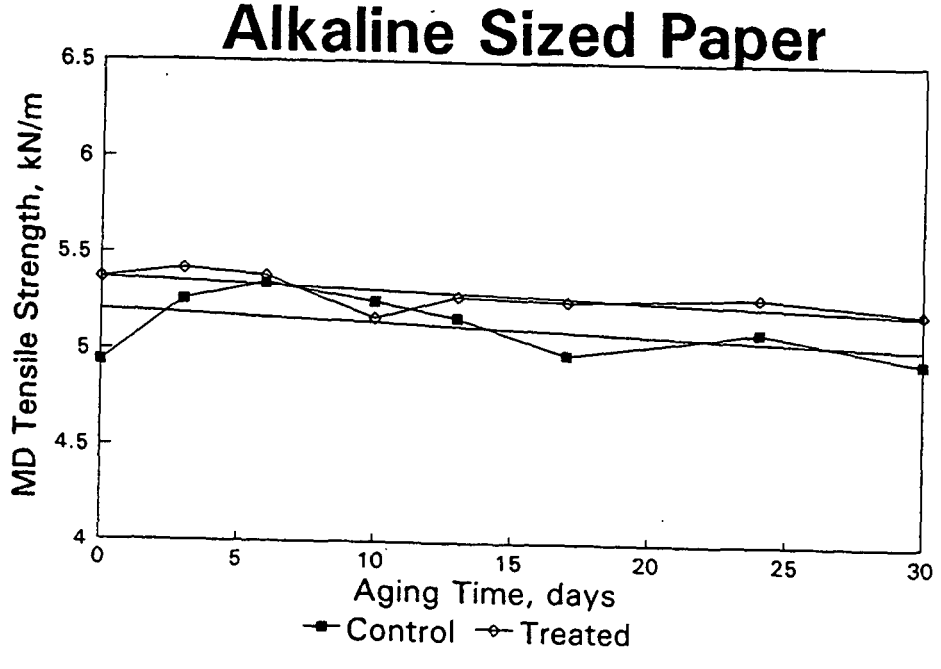

Fig. 3-AS Affect of Aging Time on MD Tensile Strength.

TABLE IV

CD TENSILE DATA (kN/m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	2.05	2.04	2.74	2.64	1.00	0.97	3.69	3.72
	Std Dev	0.10	0.08	0.17	0.16	0.02	0.04	0.18	0.33
3	Average	1.99	2.05	2.66	2.84	0.97	0.99	3.42	3.71
	Std Dev	0.11	0.08	0.22	0.08	0.05	0.02	0.10	0.10
6	Average	1.97	2.13	2.62	2.75	0.98	0.95	3.39	3.71
	Std Dev	0.09	0.11	0.17	0.18	0.04	0.06	0.11	0.13
10	Average	1.93	2.00	2.64	2.76	0.93	0.98	3.44	3.43
	Std Dev	0.06	0.14	0.12	0.17	0.06	0.03	0.14	0.21
13	Average	1.86	2.03	2.52	2.69	0.97	0.98	3.46	3.52
	Std Dev	0.07	0.11	0.15	0.12	0.03	0.03	0.18	0.19
17	Average	1.87	2.02	2.40	2.75	0.95	0.93	3.42	3.64
	Std Dev	0.07	0.13	0.14	0.14	0.05	0.03	0.11	0.11
24	Average	1.77	2.03	2.45	2.72	0.87	0.92	3.38	3.70
	Std Dev	0.06	0.08	0.14	0.17	0.05	0.04	0.09	0.13
30	Average	1.78	1.96	2.41	2.62	0.83	0.92	3.47	3.61
	Std Dev	0.10	0.08	0.20	0.15	0.03	0.03	0.16	0.13

REGRESSION STATISTICS

R Squared	0.936	0.432	0.820	0.149	0.840	0.650	0.153	0.032
Coefficient	-0.009	-0.003	-0.011	-0.003	-0.005	-0.002	-0.004	-0.002
Std Err	0.0010	0.0014	0.0021	0.0025	0.0009	0.0007	0.0035	0.0041
Constant	2.02	2.07	2.70	2.75	1.00	0.98	3.51	3.65

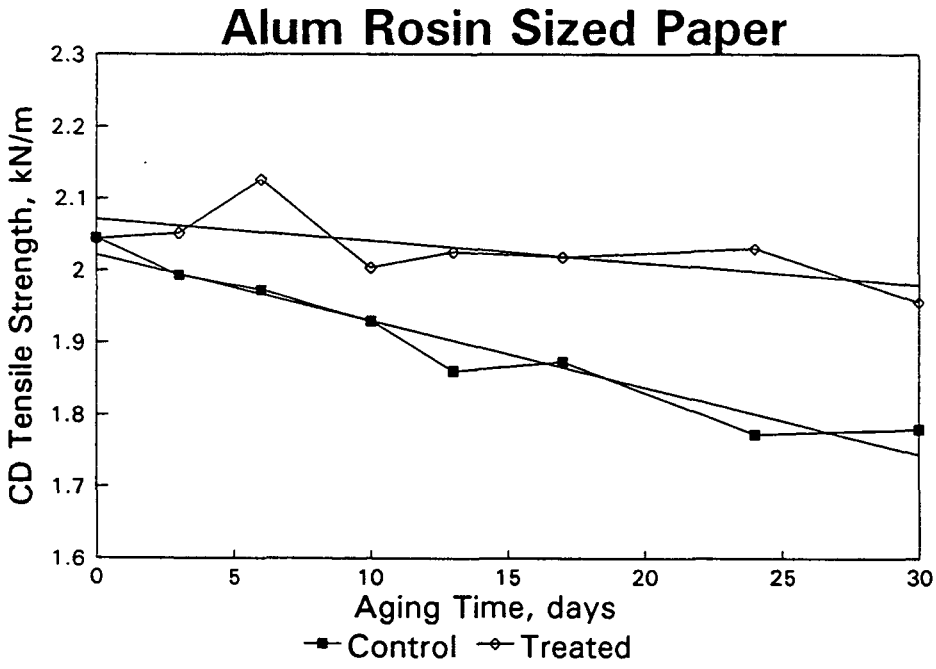

Fig. 4-AR Affect of Aging Time on CD Tensile Strength.

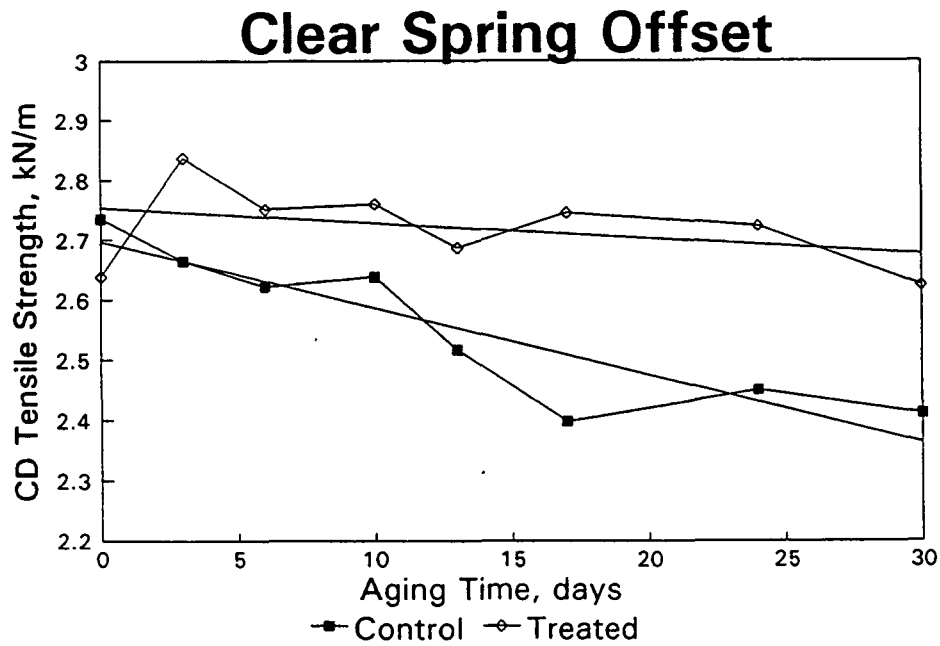

Fig. 4-CS Affect of Aging Time on CD Tensile Strength.

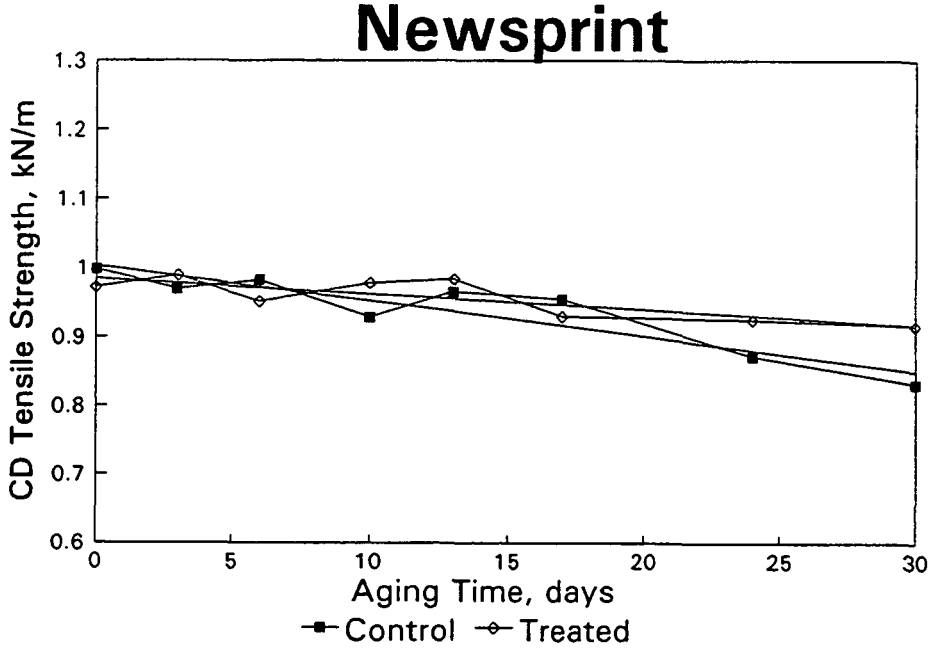

Fig. 4-NP Affect of Aging Time on CD Tensile Strength.

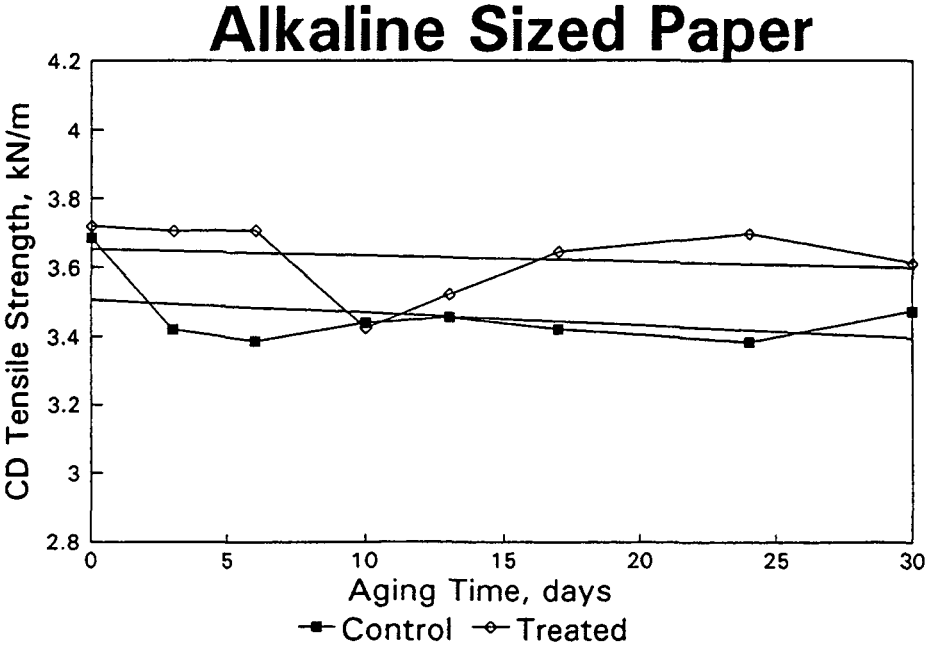

Fig. 4-AS Affect of Aging Time on CD Tensile Strength.

TABLE V

MD STRETCH DATA (%)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	1.78	1.64	1.71	1.64	1.31	1.24	1.95	2.21
	Std Dev	0.13	0.18	0.08	0.11	0.09	0.10	0.49	0.05
3	Average	1.59	1.52	1.56	1.66	1.10	1.21	2.05	2.11
	Std Dev	0.07	0.15	0.13	0.11	0.20	0.09	0.10	0.08
6	Average	1.40	1.58	1.56	1.60	1.16	1.19	2.16	2.06
	Std Dev	0.17	0.10	0.06	0.10	0.08	0.11	0.08	0.11
10	Average	1.38	1.45	1.40	1.53	1.08	1.15	2.03	2.09
	Std Dev	0.07	0.12	0.08	0.13	0.11	0.12	0.07	0.07
13	Average	1.24	1.43	1.27	1.52	1.00	1.12	1.97	2.01
	Std Dev	0.07	0.09	0.10	0.13	0.11	0.13	0.14	0.09
17	Average	1.20	1.45	1.17	1.48	0.92	1.13	2.03	2.05
	Std Dev	0.07	0.06	0.11	0.06	0.08	0.09	0.10	0.13
24	Average	1.11	1.40	1.04	1.44	0.87	1.07	1.98	2.04
	Std Dev	0.08	0.12	0.05	0.14	0.09	0.14	0.08	0.13
30	Average	1.02	1.31	0.95	1.32	0.90	0.96	1.99	2.03
	Std Dev	0.06	0.13	0.16	0.09	0.09	0.16	0.09	0.10

REGRESSION STATISTICS

R Squared	0.889	0.850	0.972	0.964	0.818	0.943	0.080	0.534
Coefficient	-0.023	-0.009	-0.026	-0.011	-0.013	-0.008	-0.002	-0.004
Std Err	0.0033	0.0016	0.0018	0.0008	0.0025	0.0008	0.0025	0.0017
Constant	1.63	1.59	1.66	1.66	1.21	1.24	2.04	2.13

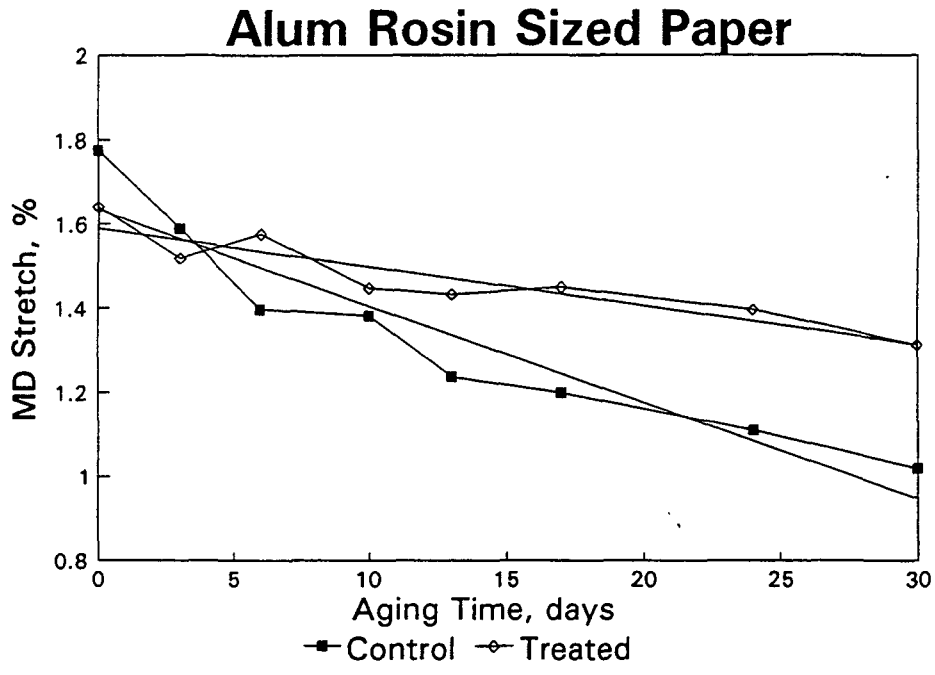

Fig. 5-AR Affect of Aging Time on MD Stretch.

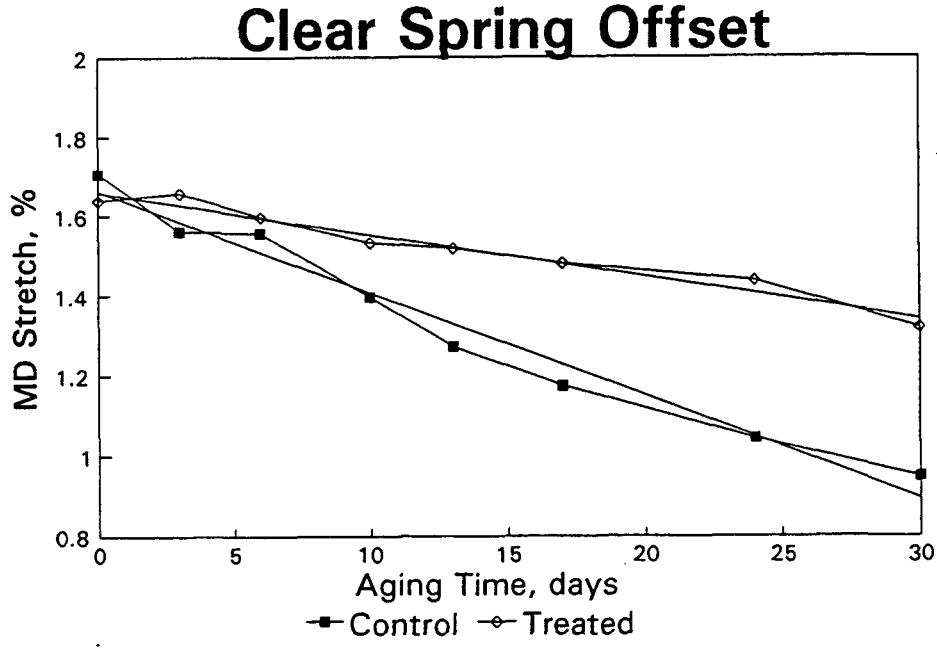

Fig. 5-CS Affect of Aging Time on MD Stretch.

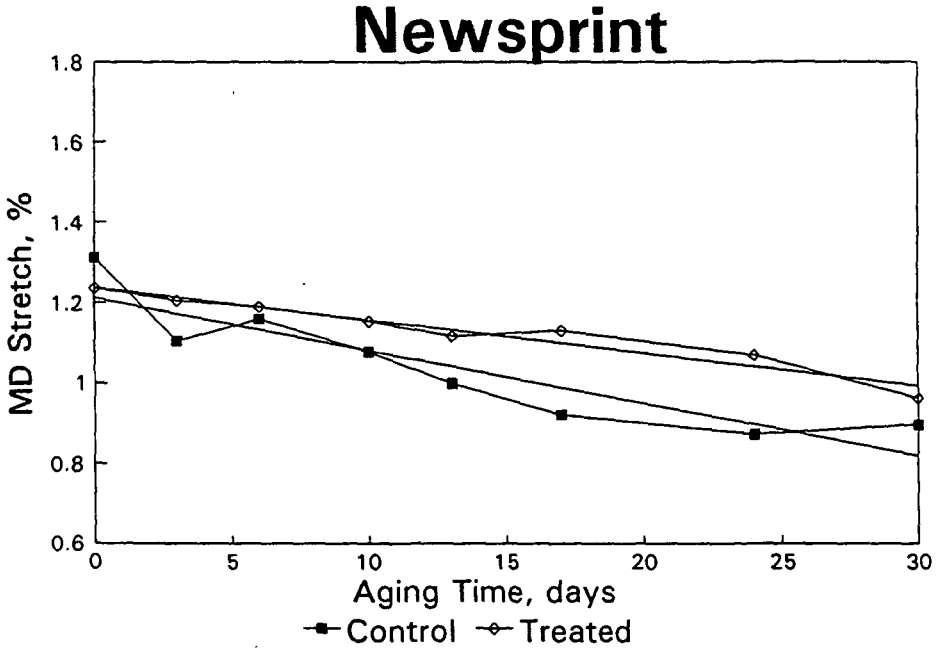

Fig. 5-NP Affect of Aging Time on MD Stretch.

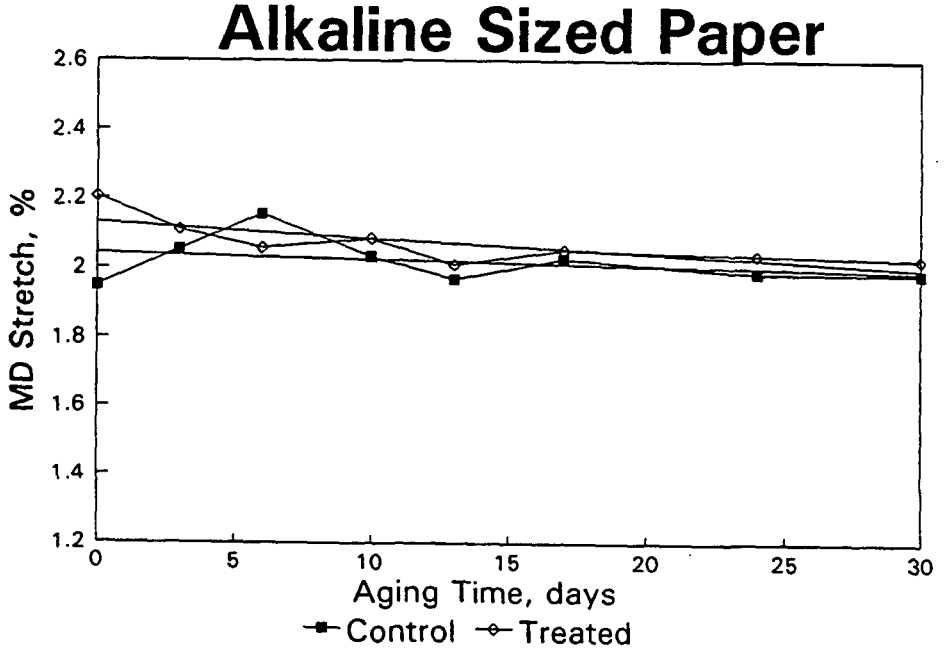

Fig. 5-AS Affect of Aging Time on MD Stretch.

TABLE VI

CD STRETCH DATA (%)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	3.39	3.19	4.48	4.38	2.46	2.31	4.28	3.91
	Std Dev	0.26	0.41	0.48	0.54	0.16	0.22	0.57	0.86
3	Average	3.21	2.84	4.11	4.56	2.17	2.16	5.05	4.10
	Std Dev	0.30	0.45	0.29	0.33	0.21	0.20	0.39	0.38
6	Average	2.79	2.93	4.01	4.27	2.05	2.00	4.91	3.86
	Std Dev	0.30	0.46	0.25	0.51	0.19	0.27	0.38	0.32
10	Average	2.34	2.48	3.76	4.16	1.78	2.00	4.81	4.46
	Std Dev	0.26	0.44	0.19	0.40	0.21	0.08	0.40	0.49
13	Average	2.26	2.59	3.60	3.93	1.79	1.91	4.78	4.69
	Std Dev	0.27	0.38	0.48	0.38	0.18	0.12	0.51	0.38
17	Average	1.96	2.46	3.17	3.84	1.57	1.89	4.98	3.80
	Std Dev	0.21	0.38	0.43	0.38	0.20	0.15	0.40	0.32
24	Average	1.88	2.30	2.75	3.77	1.46	1.80	4.63	3.84
	Std Dev	0.19	0.29	0.29	0.29	0.23	0.23	0.34	0.38
30	Average	1.72	2.18	2.51	3.39	1.29	1.74	4.64	3.63
	Std Dev	0.17	0.21	0.44	0.44	0.14	0.14	0.42	0.59

REGRESSION STATISTICS

R Squared	0.883	0.863	0.987	0.925	0.933	0.876	0.001	0.119
Coefficient	-0.056	-0.030	-0.066	-0.035	-0.036	-0.017	-0.001	-0.012
Std Err	0.0084	0.0049	0.0031	0.0041	0.0040	0.0026	0.0097	0.0134
Constant	3.17	3.01	4.40	4.49	2.29	2.19	4.77	4.19

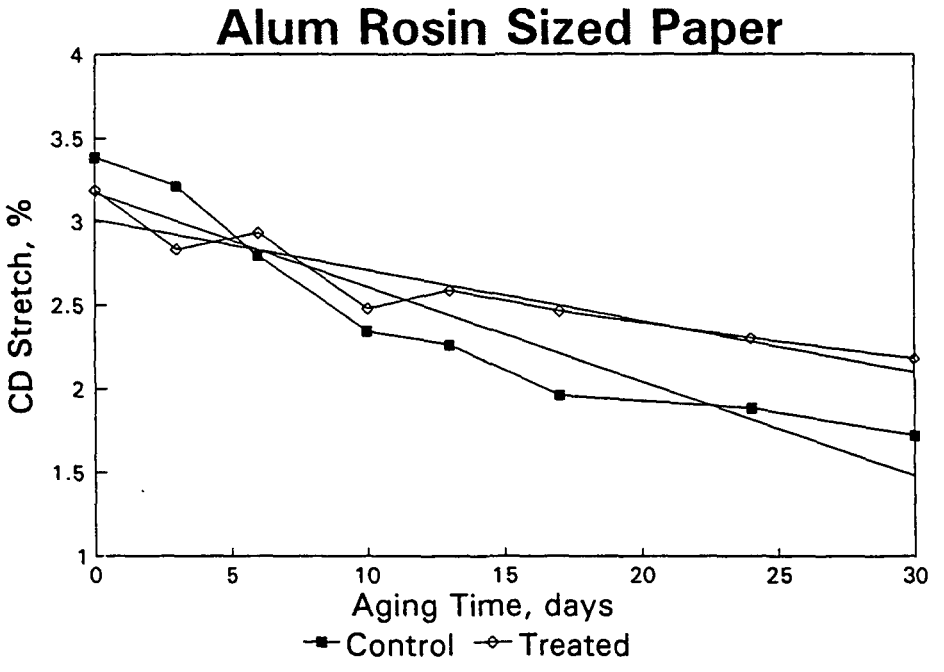

Fig. 6-AR Affect of Aging Time on CD Stretch.

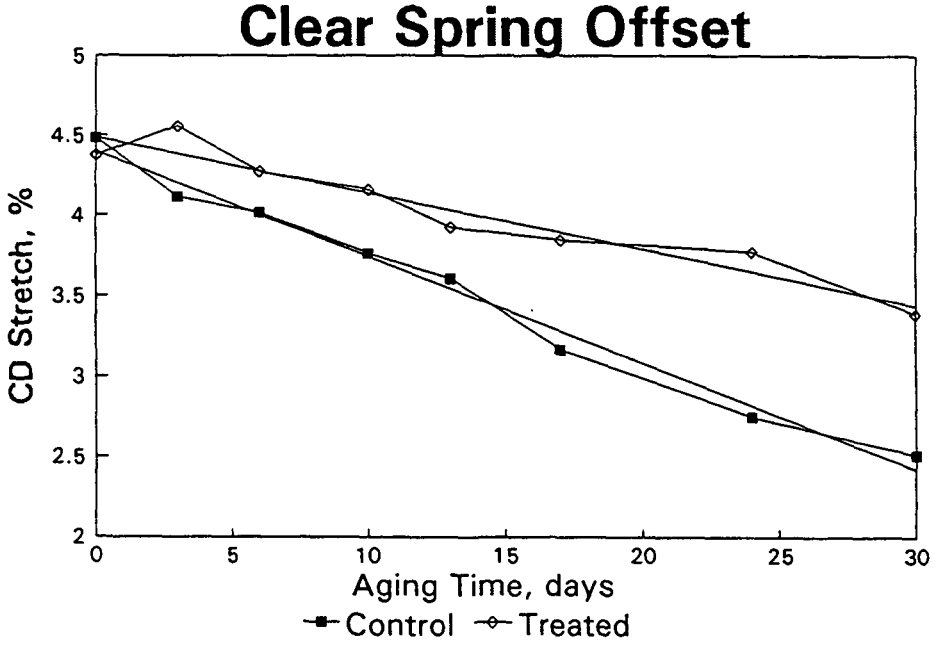

Fig. 6-CS Affect of Aging Time on CD Stretch.

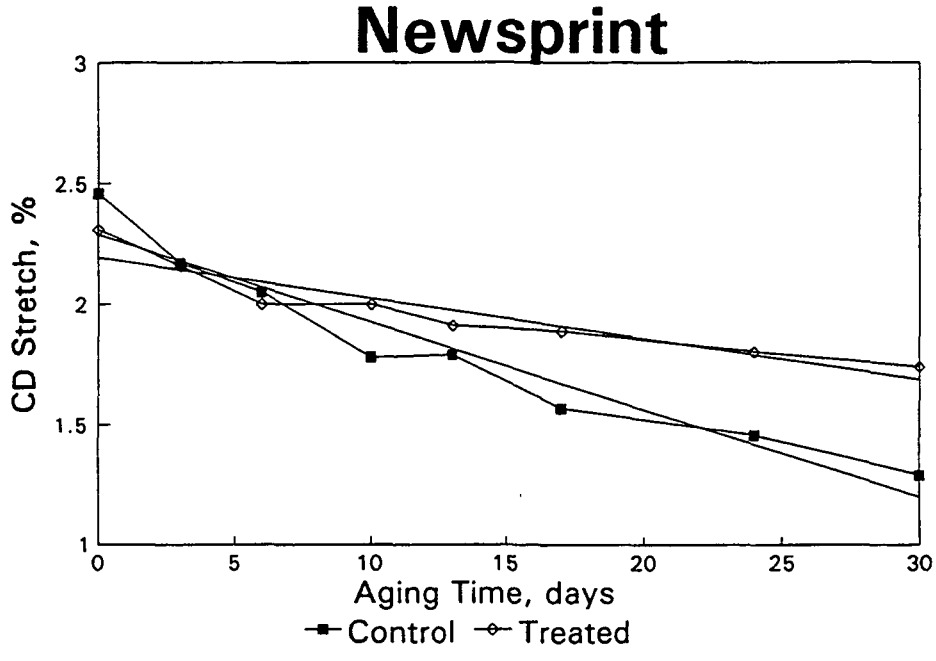

Fig. 6-NP Affect of Aging Time on CD Stretch.

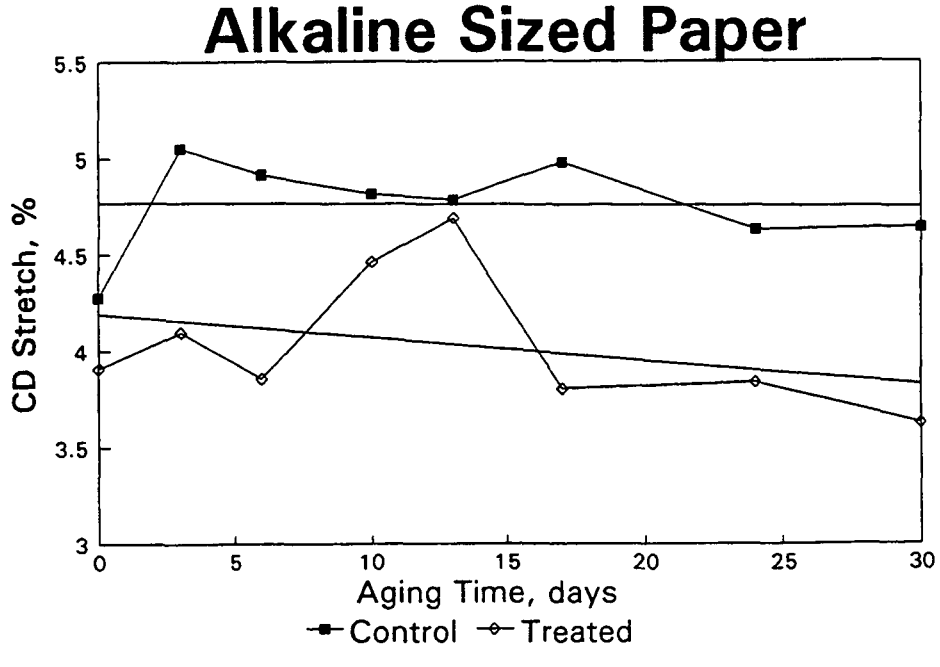

Fig. 6-AS Affect of Aging Time on CD Stretch.

TABLE VII

MD TEA DATA (J/sq m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	58.2	52.3	88.3	82.5	21.0	19.3	67.2	81.5
	Std Dev	6.8	9.9	5.9	7.9	2.8	2.6	21.6	2.7
3	Average	51.2	44.5	77.3	84.9	16.3	17.7	74.0	78.8
	Std Dev	4.6	7.6	11.3	9.3	5.1	3.1	5.6	2.5
6	Average	42.4	50.8	77.0	80.2	17.9	18.3	79.6	75.3
	Std Dev	8.9	6.3	4.6	8.6	2.1	2.8	5.2	5.8
10	Average	41.9	42.9	64.1	76.0	16.0	17.3	72.5	74.2
	Std Dev	4.5	7.2	6.0	10.4	2.5	3.0	3.7	3.6
13	Average	35.4	42.3	56.0	75.2	14.3	16.4	70.1	73.0
	Std Dev	3.7	3.1	6.9	9.5	2.7	3.3	7.3	3.8
17	Average	32.5	43.7	48.9	71.0	12.3	17.5	69.1	74.3
	Std Dev	3.8	4.6	7.7	4.3	1.8	3.0	6.0	6.3
24	Average	28.6	40.9	39.8	69.2	10.9	15.8	69.3	74.1
	Std Dev	4.1	7.4	3.4	10.7	1.7	3.9	5.8	6.9
30	Average	24.1	35.7	33.5	59.1	10.7	13.0	67.7	72.5
	Std Dev	2.9	6.7	9.2	6.3	1.8	4.0	4.0	4.6

REGRESSION STATISTICS

R Squared	0.916	0.746	0.966	0.943	0.869	0.833	0.185	0.619
Coefficient	-1.061	-0.443	-1.846	-0.779	-0.322	-0.170	-0.170	-0.235
Std Err	0.1311	0.1053	0.1420	0.0780	0.0510	0.0311	0.1458	0.0753
Constant	52.9	49.8	84.4	84.8	19.1	19.1	73.4	78.5

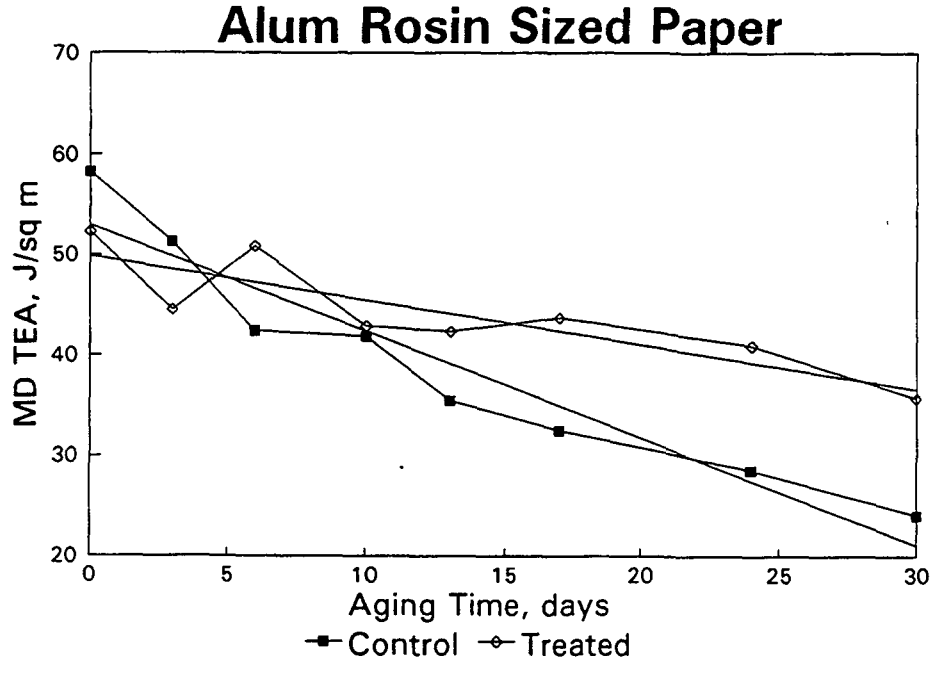

Fig. 7-AR Affect of Aging Time on MD Tensile Energy Absorption.

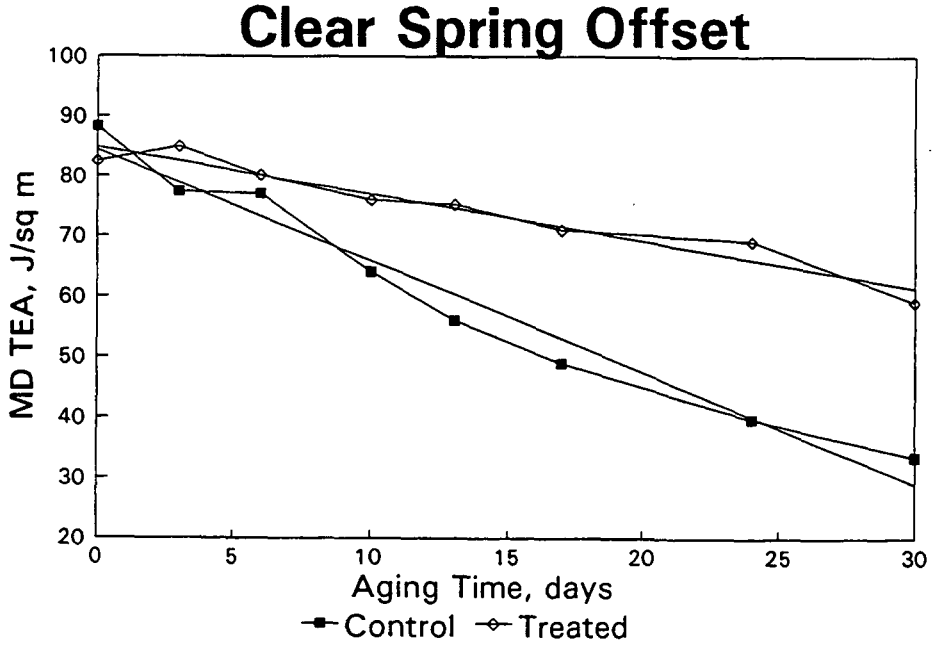

Fig. 7-CS Affect of Aging Time on MD Tensile Energy Absorption.

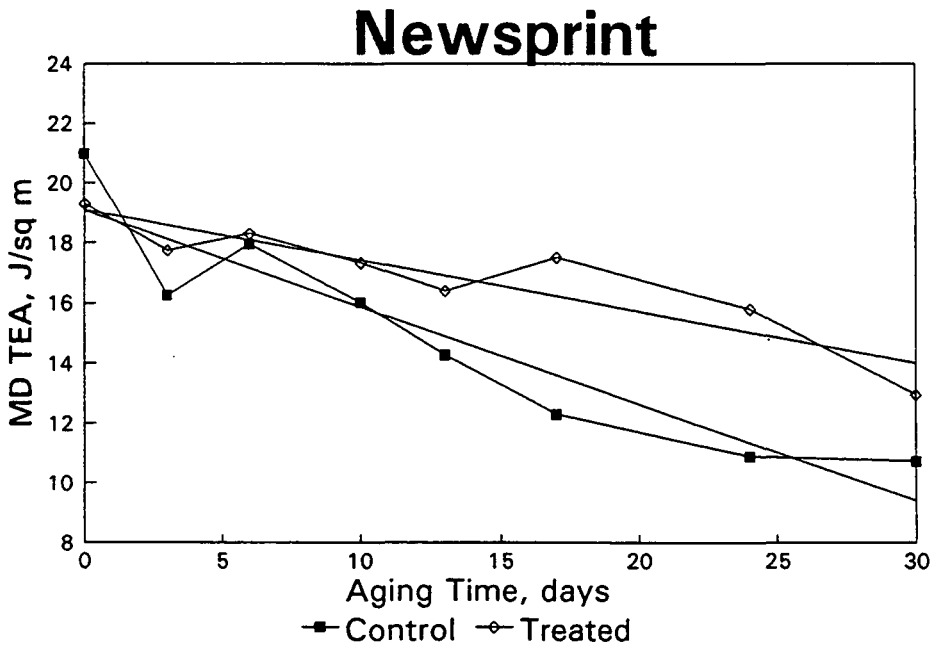

Fig. 7-NP Affect of Aging Time on MD Tensile Energy Absorption.

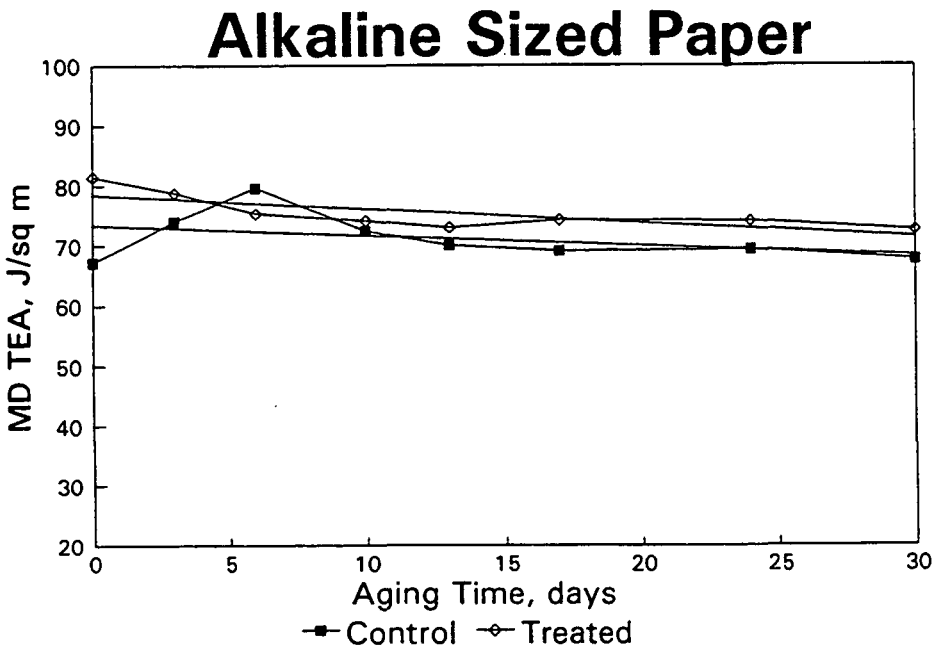

Fig. 7-AS Affect of Aging Time on MD Tensile Energy Absorption.

TABLE VIII

CD TEA DATA (J/sq m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	54.8	51.1	101.4	95.3	17.0	15.6	120.3	112.2
	Std Dev	5.9	7.5	14.3	12.9	1.4	2.2	17.5	29.3
3	Average	50.5	44.4	90.3	107.3	14.1	14.3	135.2	116.4
	Std Dev	7.9	9.1	8.0	7.8	2.3	1.9	13.0	11.5
6	Average	43.3	47.9	87.8	97.8	13.5	12.6	130.3	109.2
	Std Dev	6.3	7.6	8.4	15.2	1.9	2.7	13.4	10.2
10	Average	34.3	38.0	82.7	95.7	10.8	13.2	129.3	119.5
	Std Dev	4.2	8.9	6.3	13.4	2.3	0.9	14.2	14.0
13	Average	32.2	39.9	74.1	88.1	11.4	12.3	130.2	129.9
	Std Dev	5.1	8.2	7.9	10.0	1.8	1.4	18.4	14.3
17	Average	27.4	38.3	62.5	87.2	9.7	11.8	134.0	106.2
	Std Dev	4.1	7.9	11.4	11.2	1.6	1.0	12.6	8.4
24	Average	24.7	35.5	54.1	85.8	8.3	11.1	123.0	109.1
	Std Dev	3.7	6.4	5.3	11.2	1.8	2.0	11.5	12.3
30	Average	22.5	32.1	49.6	72.6	6.5	10.4	126.9	100.9
	Std Dev	3.2	4.2	13.4	10.9	1.1	1.3	15.7	19.4

REGRESSION STATISTICS

R Squared	0.885	0.842	0.968	0.795	0.934	0.878	0.012	0.203
Coefficient	-1.095	-0.568	-1.752	-0.886	-0.315	-0.153	-0.055	-0.389
Std Err	0.1610	0.1006	0.1301	0.1835	0.0342	0.0233	0.1989	0.3144
Constant	50.3	48.2	97.9	102.6	15.5	14.6	129.4	117.9

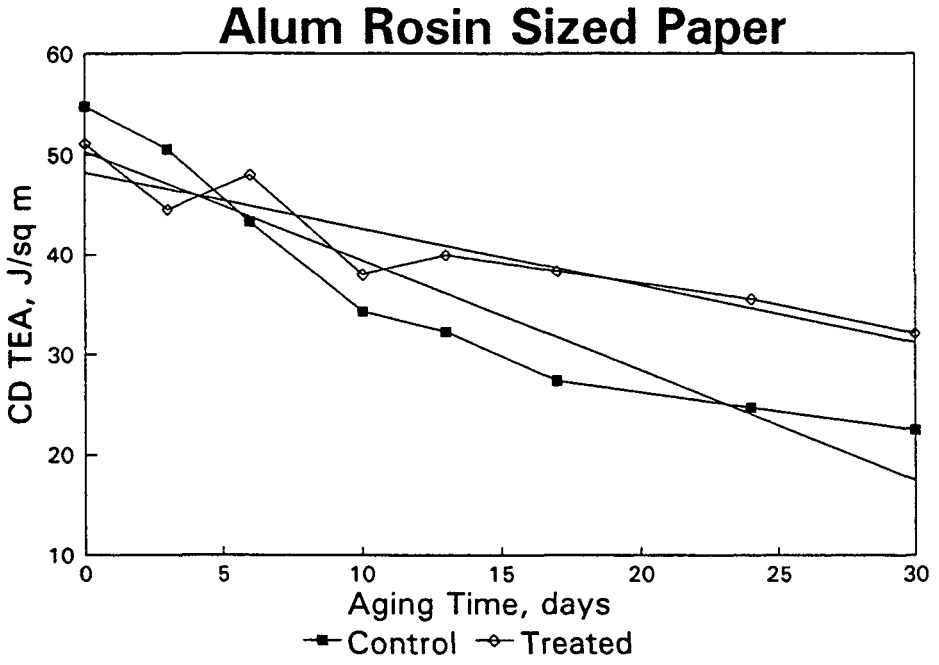

Fig. 8-AR Affect of Aging Time on CD Tensile Energy Absorption.

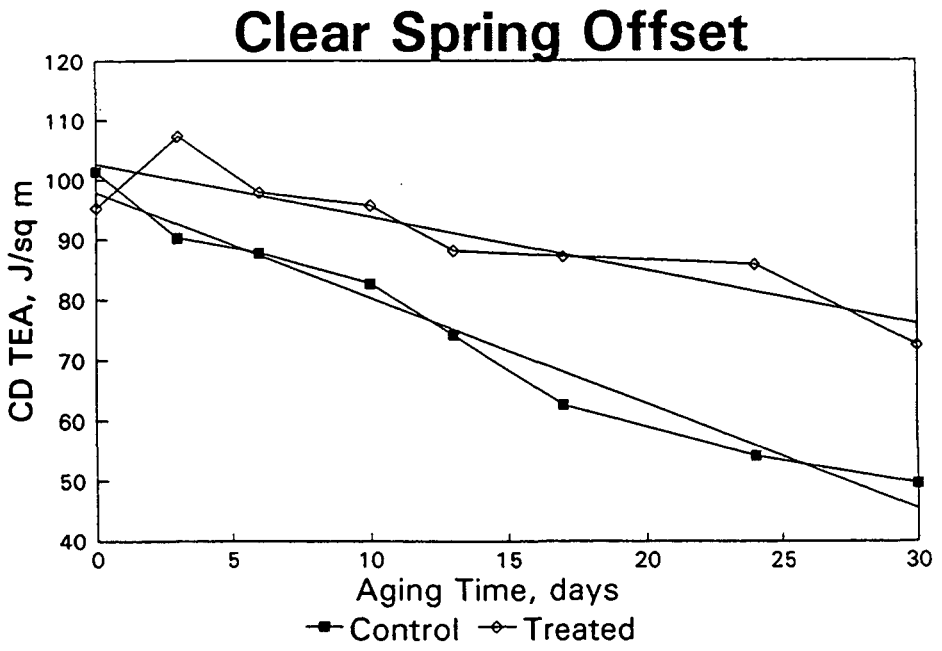

Fig. 8-CS Affect of Aging Time on CD Tensile Energy Absorption.

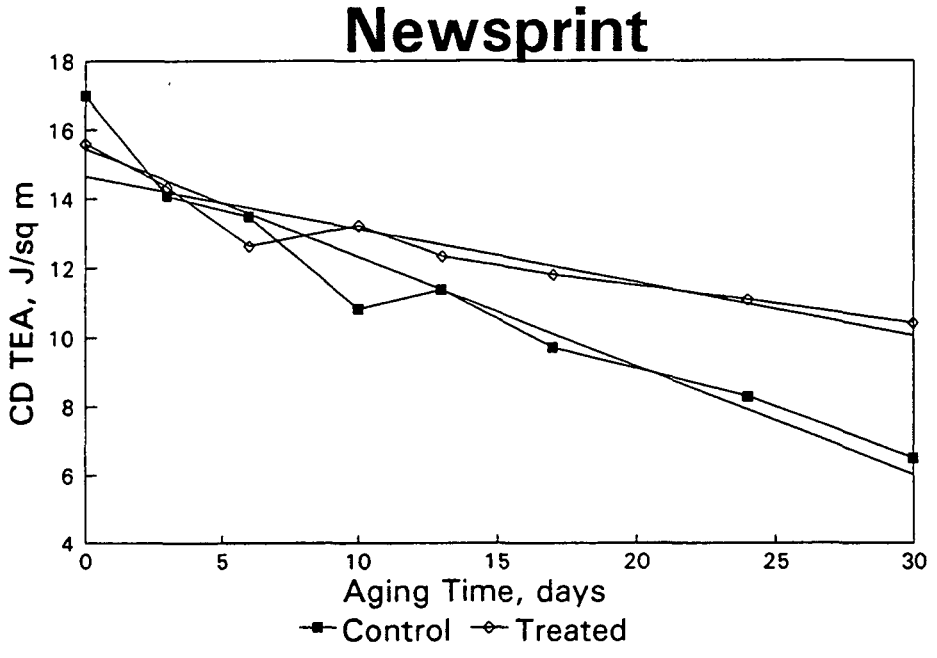

Fig. 8-NP Affect of Aging Time on CD Tensile Energy Absorption.

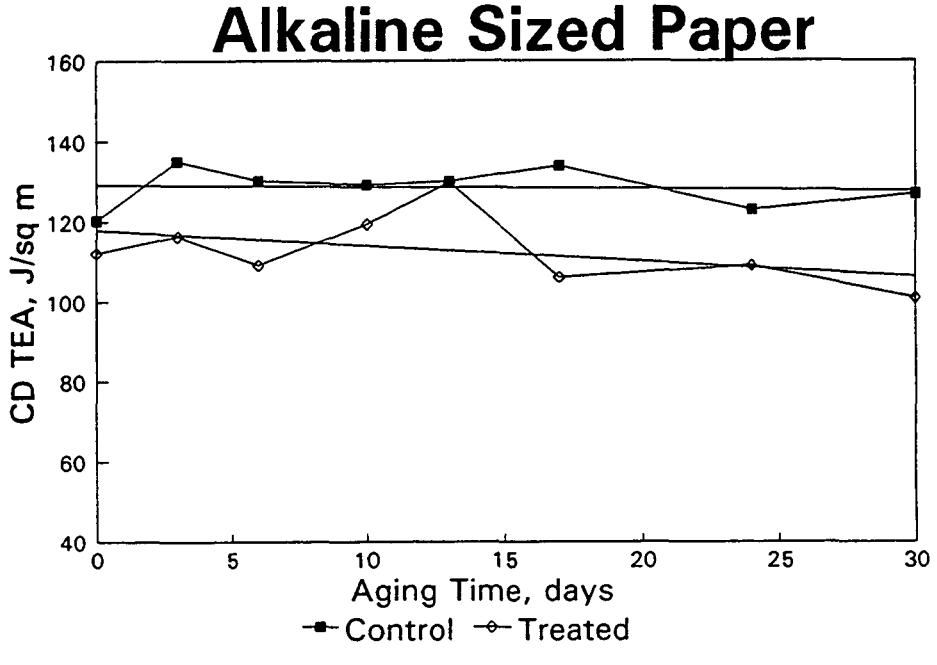

Fig. 8-AS Affect of Aging Time on CD Tensile Energy Absorption.

TABLE IX

MD TENSILE STIFFNESS DATA (kN/m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	606	614	937	933	330	331	615	619
	Std Dev	14	20	9	18	10	9	22	14
3	Average	623	596	936	935	341	321	625	631
	Std Dev	23	15	14	11	12	12	17	23
6	Average	636	617	941	948	344	334	628	631
	Std Dev	14	25	17	18	11	9	18	17
10	Average	652	613	945	943	349	333	630	611
	Std Dev	20	38	10	17	11	8	21	15
13	Average	656	621	973	964	360	342	636	642
	Std Dev	19	25	18	14	11	4	23	19
17	Average	642	617	959	953	345	340	608	626
	Std Dev	25	29	12	24	12	7	14	12
24	Average	632	617	950	951	341	344	612	616
	Std Dev	25	33	7	20	24	14	21	13
30	Average	624	604	966	965	348	345	610	627
	Std Dev	22	21	20	22	14	13	12	20

REGRESSION STATISTICS

R Squared	0.041	0.002	0.493	0.617	0.128	0.071	0.242	0.003
Coefficient	0.324	0.031	0.930	0.898	0.296	0.657	-0.501	-0.048
Std Err	0.6389	0.3235	0.3848	0.2892	0.3156	0.1703	0.3618	0.3894
Constant	630	612	939	938	341	328	627	626

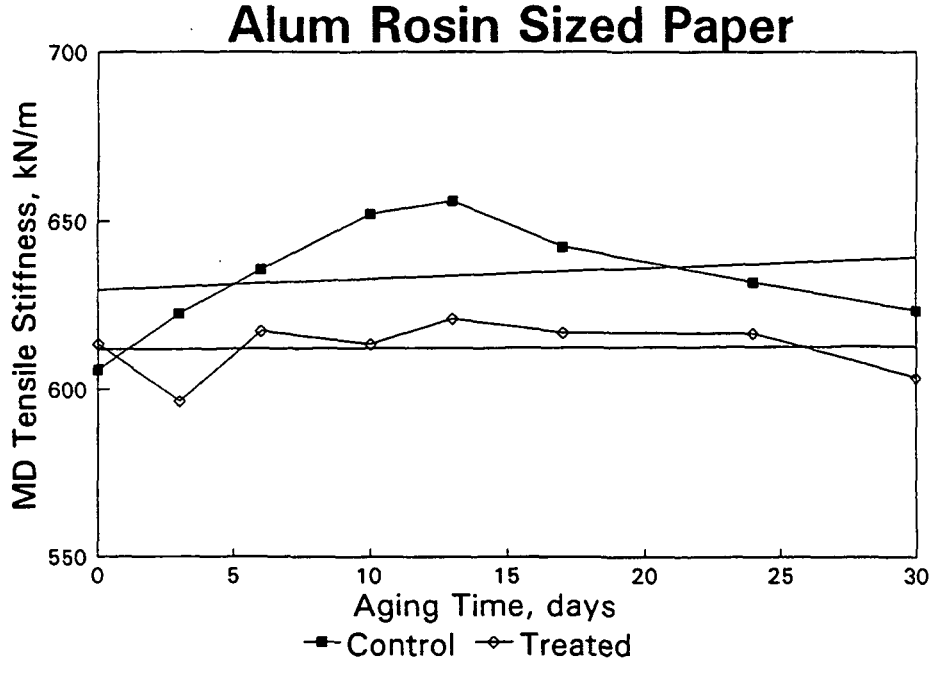

Fig. 9-AR Affect of Aging Time on MD Tensile Stiffness (Et).

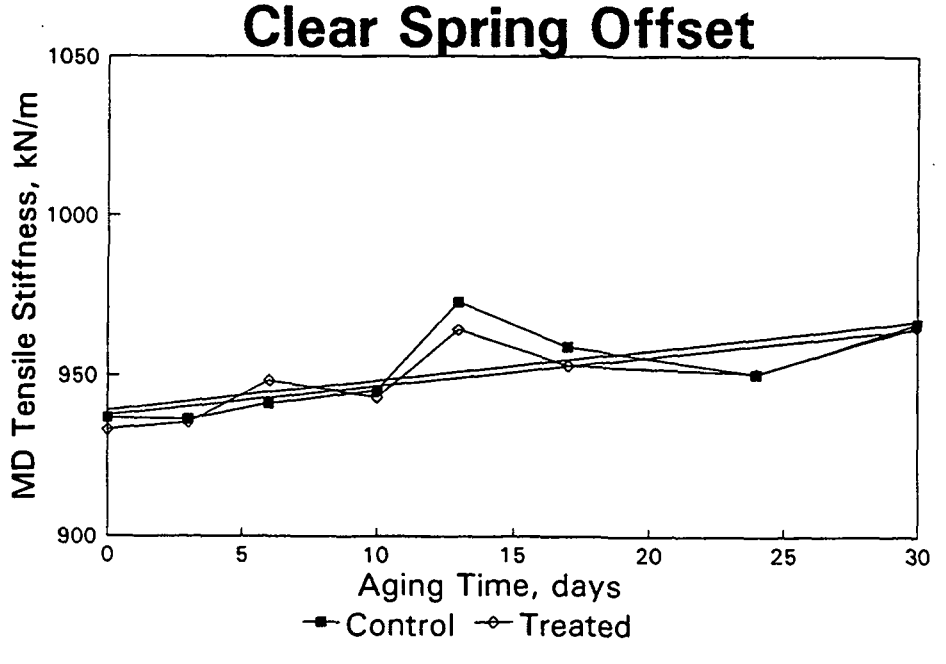

Fig. 9-CS Affect of Aging Time on MD Tensile Stiffness (Et).

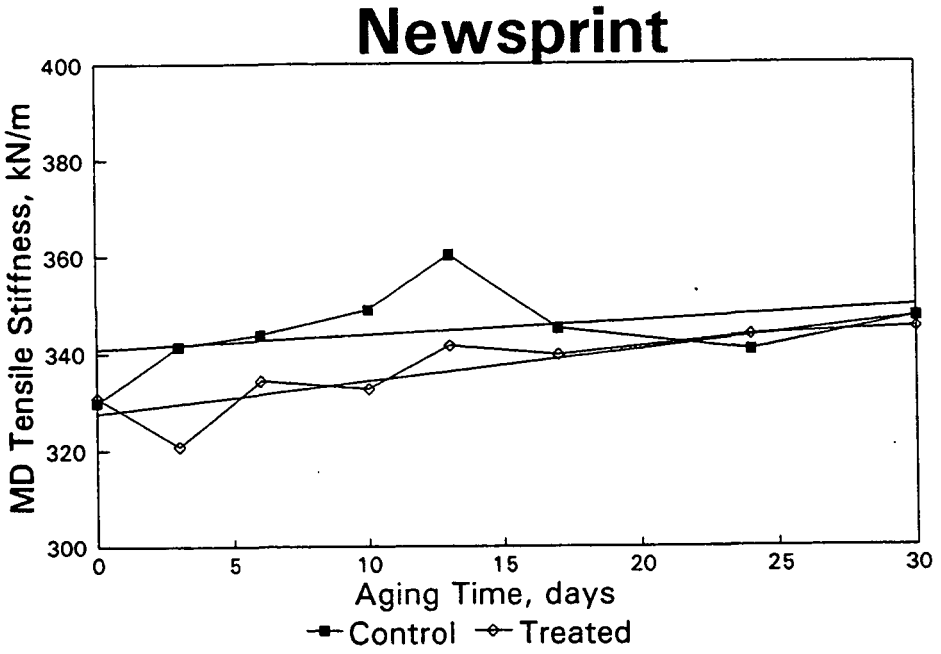

Fig. 9-NP Affect of Aging Time on MD Tensile Stiffness (Et).

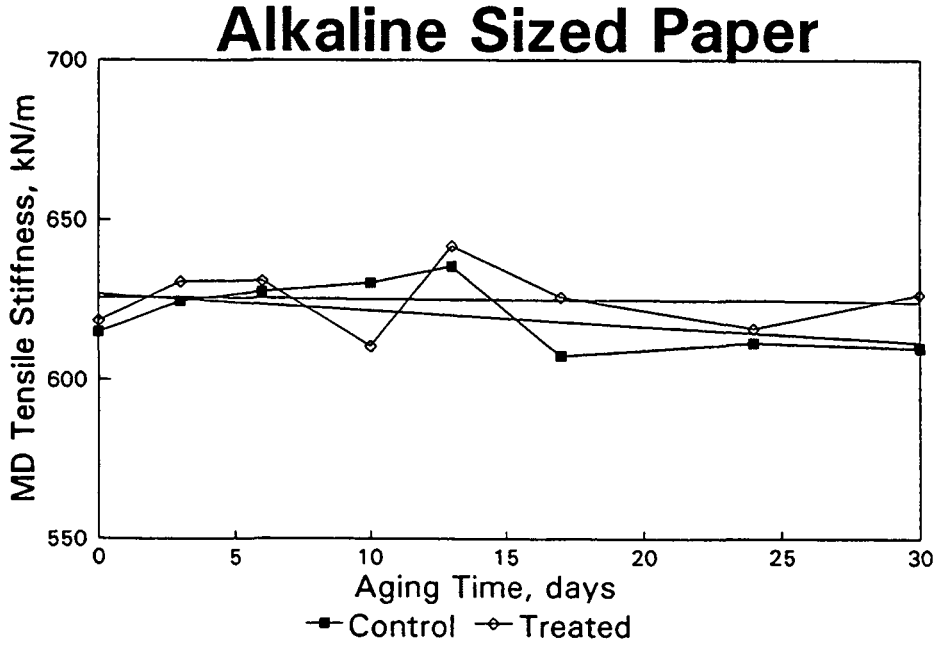

Fig. 9-AS Affect of Aging Time on MD Tensile Stiffness (Et).

TABLE X

CD TENSILE STIFFNESS DATA (kN/m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	263	266	339	330	95	95	396	410
	Std Dev	11	13	18	17	3	5	17	17
3	Average	257	268	335	348	94	96	368	406
	Std Dev	9	7	24	12	3	3	9	11
6	Average	264	277	337	344	98	95	371	413
	Std Dev	12	18	18	18	4	3	7	12
10	Average	269	268	346	345	95	98	372	382
	Std Dev	10	7	10	15	2	3	11	16
13	Average	269	275	341	348	101	100	383	391
	Std Dev	9	10	24	14	3	4	4	14
17	Average	281	277	337	355	105	94	372	413
	Std Dev	7	10	16	14	9	5	14	13
24	Average	269	279	347	347	100	94	371	409
	Std Dev	8	6	16	18	8	3	8	13
30	Average	277	276	358	343	104	97	388	417
	Std Dev	13	13	18	22	5	5	9	11

REGRESSION STATISTICS

R Squared	0.570	0.530	0.646	0.154	0.640	0.000	0.000	0.061
Coefficient	0.555	0.350	0.582	0.268	0.327	-0.000	0.019	0.292
Std Err	0.1967	0.1347	0.1758	0.2568	0.0999	0.0805	0.3962	0.4663
Constant	261	269	335	342	95	96	378	401

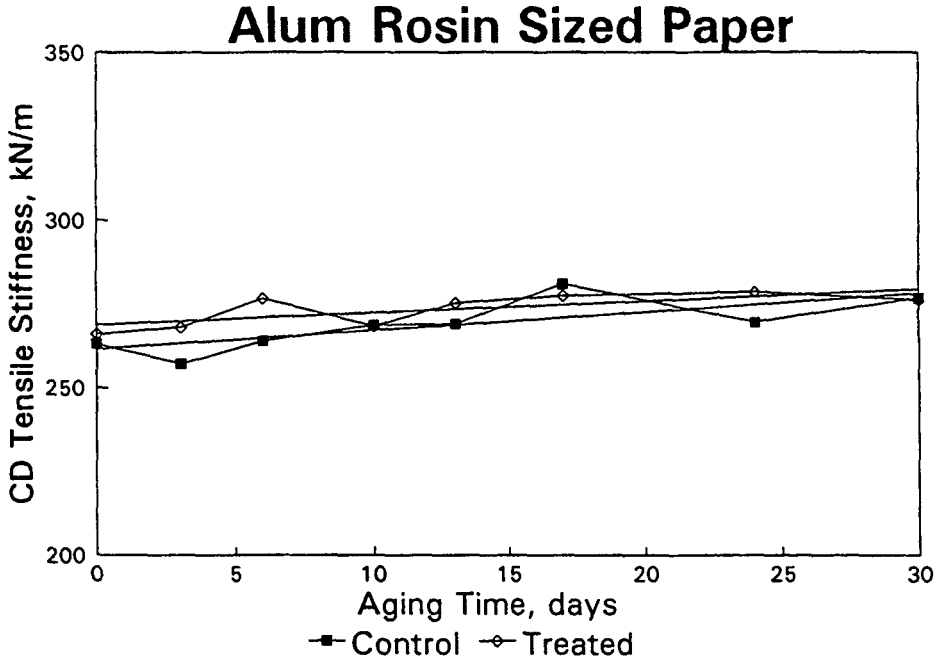

Fig.10-AR Affect of Aging Time on CD Tensile Stiffness (Et).

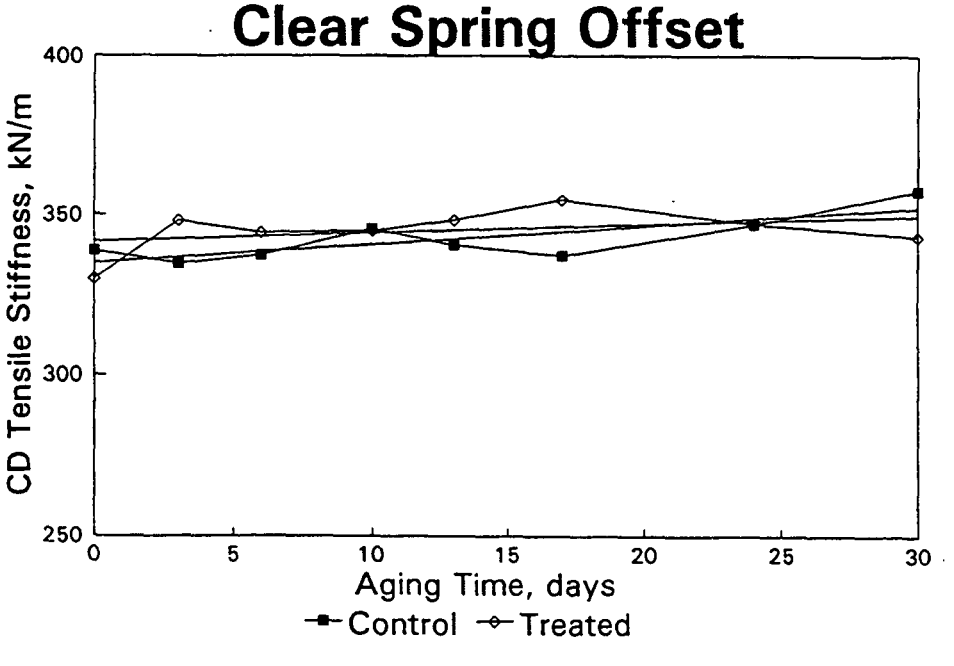

Fig.10-CS Affect of Aging Time on CD Tensile Stiffness (Et).

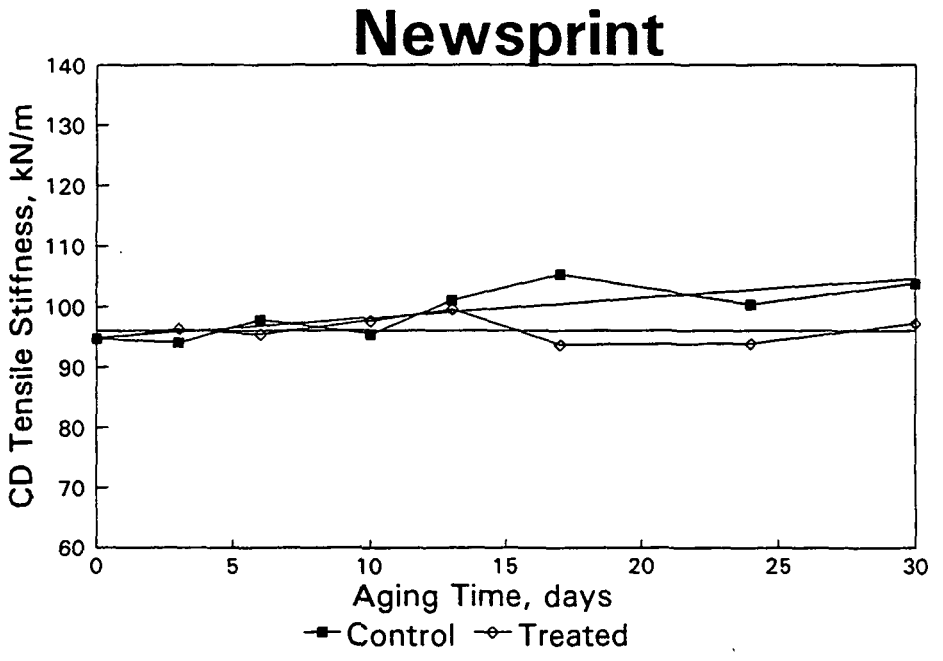

Fig.10-NP Affect of Aging Time on CD Tensile Stiffness (Et).

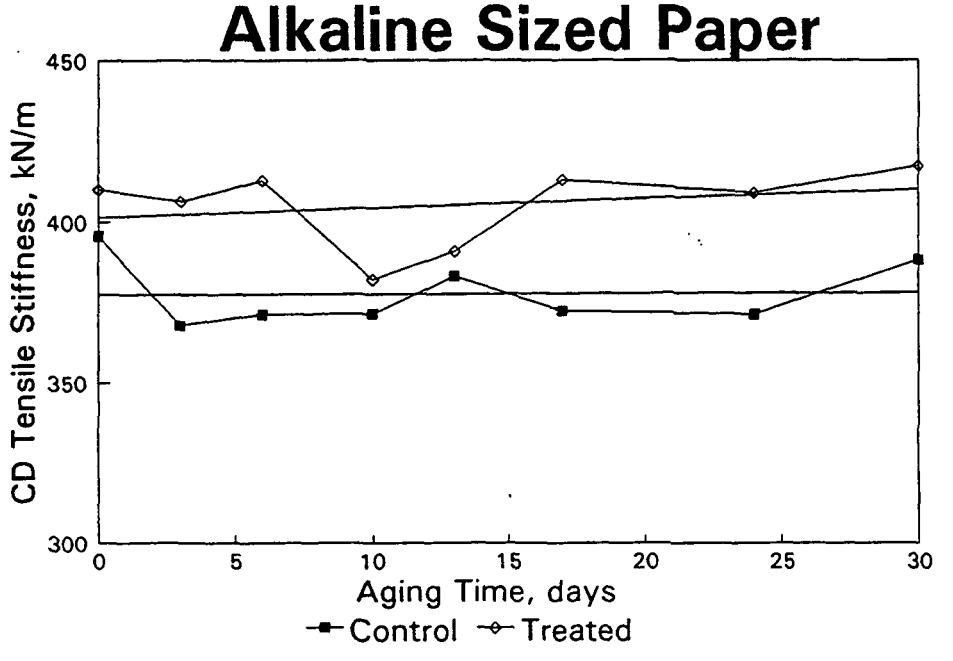

Fig.10-AS Affect of Aging Time on CD Tensile Stiffness (Et).

TABLE XI

MD TEAR DATA (mN)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	347	365	785	802	196	180	610	569
	Std Dev	13	30	35	52	9	12	11	16
3	Average	304	328	700	732	165	166	592	555
	Std Dev	14	13	31	44	10	12	12	23
6	Average	288	304	614	720	147	173	590	575
	Std Dev	19	10	19	21	10	12	14	13
10	Average	261	300	524	714	122	159	549	549
	Std Dev	9	23	31	21	8	11	13	13
13	Average	222	267	479	598	98	118	549	577
	Std Dev	13	21	17	21	9	0	29	21
17	Average	218	271	426	602	78	127	577	543
	Std Dev	17	33	13	13	0	10	10	23
24	Average	182	241	310	526	78	100	514	534
	Std Dev	16	19	15	24	0	6	20	12
30	Average	167	235	288	510	63	98	530	518
	Std Dev	10	0	9	16	8	0	23	17

REGRESSION STATISTICS

R Squared	0.940	0.893	0.951	0.926	0.881	0.887	0.746	0.656
Coefficient	-5.836	-4.011	-16.66	-9.849	-4.290	-3.020	-2.799	-1.619
Std Err	0.6019	0.5677	1.5370	1.1339	0.6437	0.4410	0.6671	0.4787
Constant	324	340	730	777	174	179	600	573

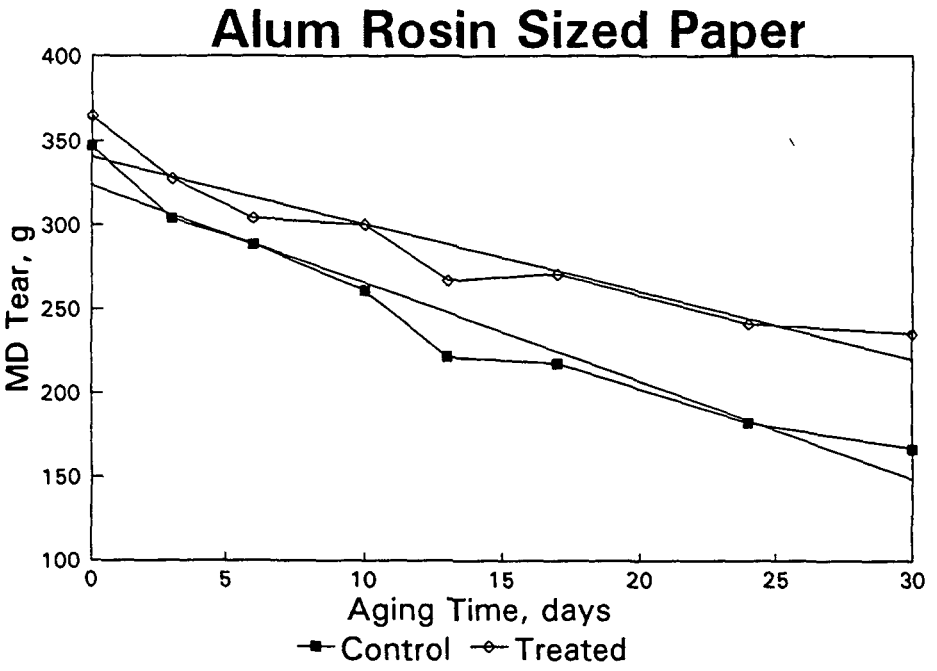

Fig.11-AR Affect of Aging Time on MD Tear Resistance.

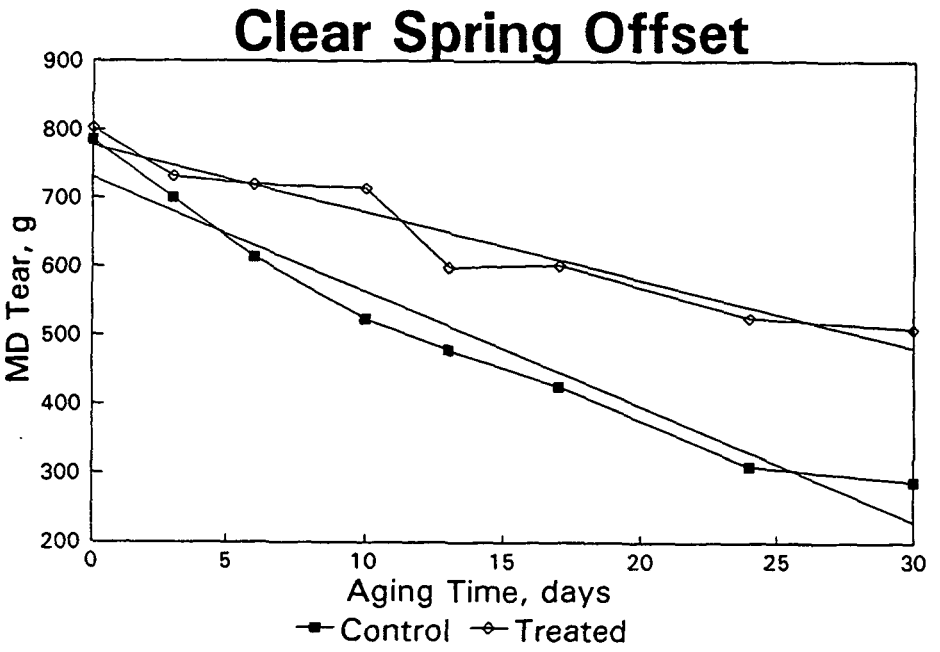

Fig.11-CS Affect of Aging Time on MD Tear Resistance.

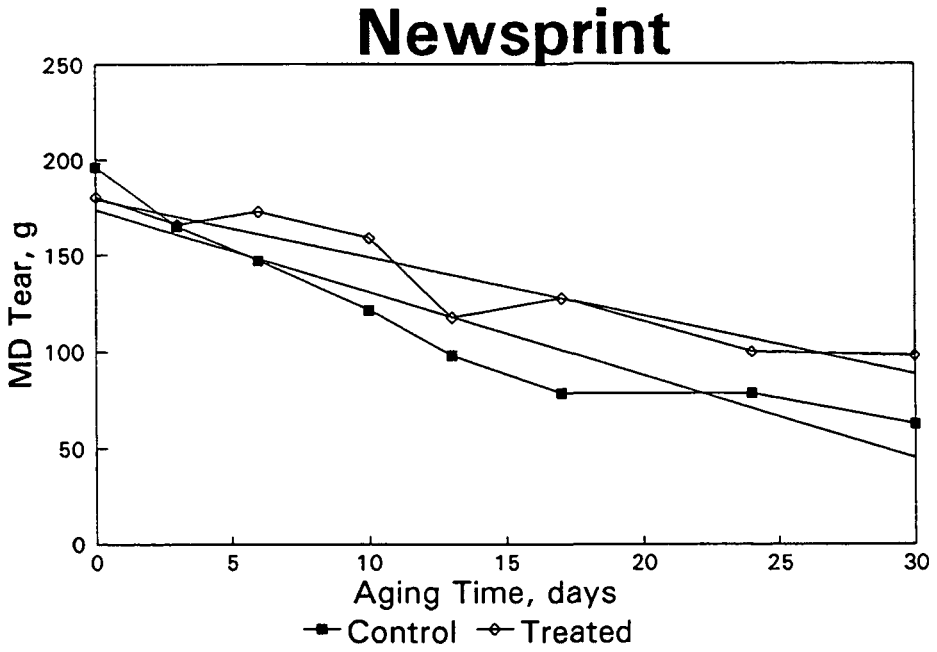

Fig.11-NP Affect of Aging Time on MD Tear Resistance.

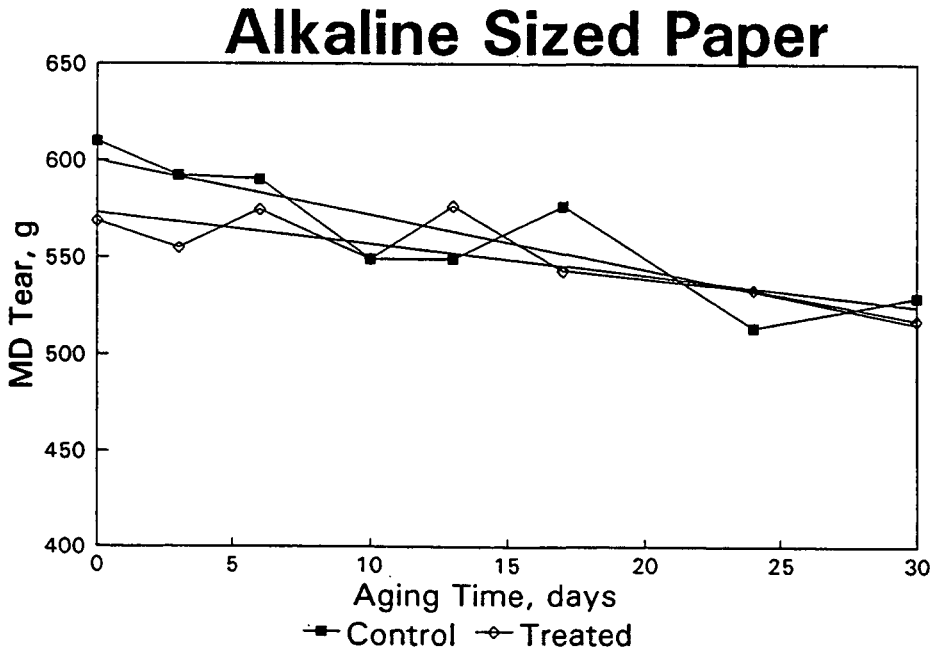

Fig.11-AS Affect of Aging Time on MD Tear Resistance.

TABLE XII

CD TEAR DATA (mN)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	408	422	889	924	288	282	561	575
	Std Dev	12	14	19	35	13	19	10	13
3	Average	367	398	830	851	237	243	549	545
	Std Dev	15	16	25	32	6	10	26	12
6	Average	355	381	732	816	231	237	579	543
	Std Dev	17	10	31	36	8	6	32	19
10	Average	314	367	620	832	204	233	553	581
	Std Dev	9	13	10	26	10	6	20	25
13	Average	261	326	555	759	153	190	504	494
	Std Dev	9	10	16	23	8	13	16	15
17	Average	253	312	514	679	131	194	522	512
	Std Dev	11	11	12	17	9	6	14	6
24	Average	228	302	379	647	118	165	522	508
	Std Dev	10	14	13	21	0	10	17	30
30	Average	200	273	324	602	112	157	512	522
	Std Dev	8	11	10	13	9	0	14	21

REGRESSION STATISTICS

R Squared	0.932	0.947	0.969	0.945	0.885	0.911	0.554	0.391
Coefficient	-6.889	-4.882	-19.26	-10.49	-5.909	-3.979	-1.896	-1.897
Std Err	0.7575	0.4732	1.4133	1.0299	0.8715	0.5079	0.6950	0.9657
Constant	387	410	853	899	260	264	562	559

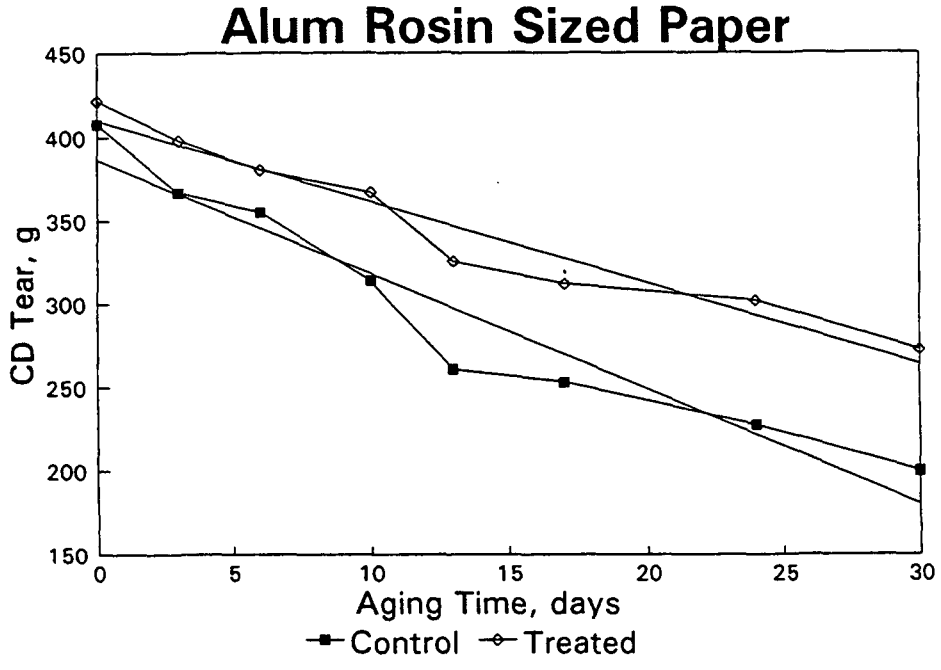

Fig.12-AR Affect of Aging Time on CD Tear Resistance.

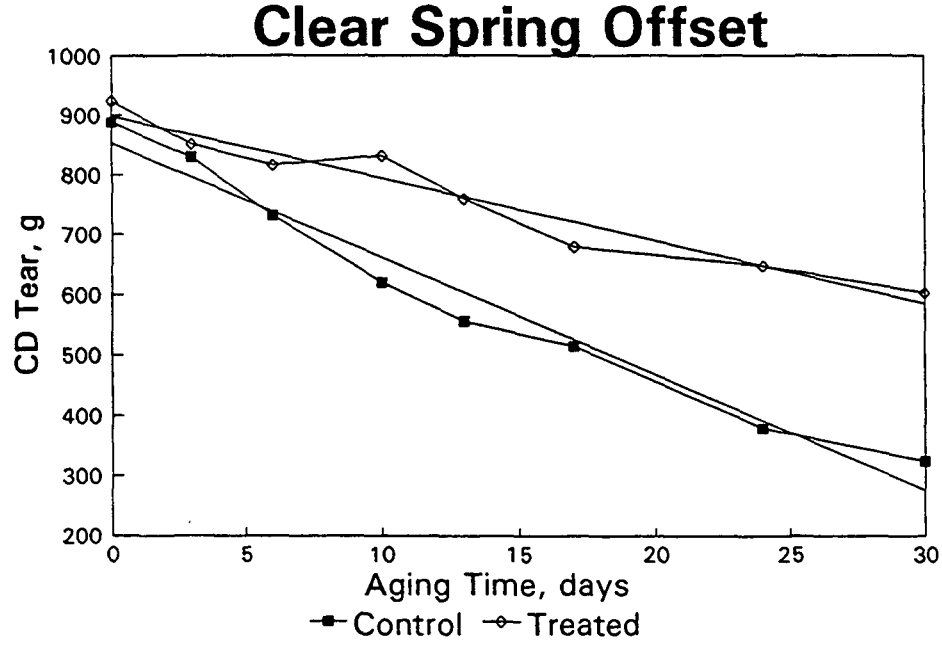

Fig.12-CS Affect of Aging Time on CD Tear Resistance.

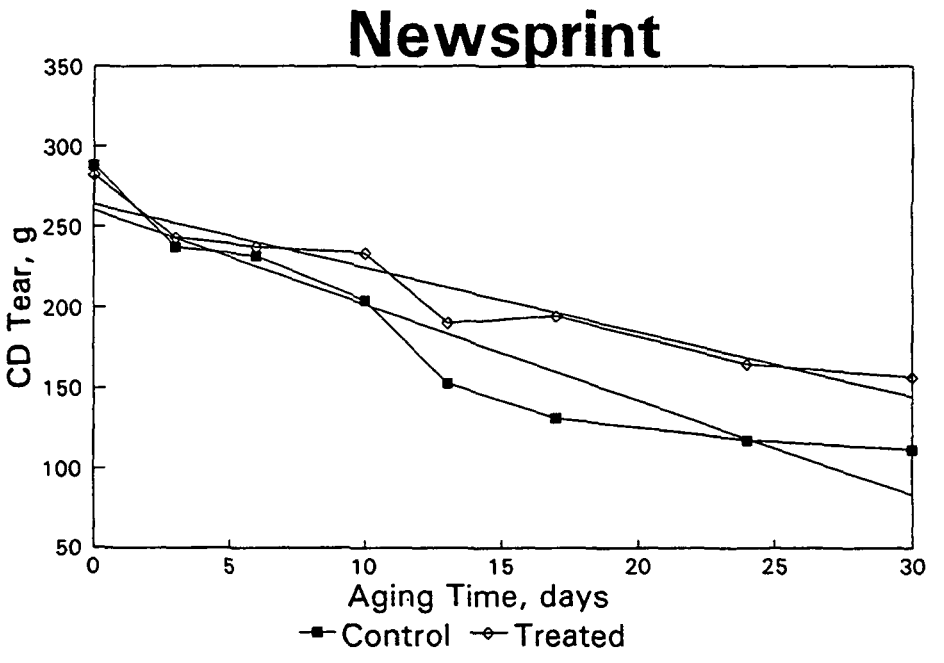

Fig.12-NP Affect of Aging Time on CD Tear Resistance.

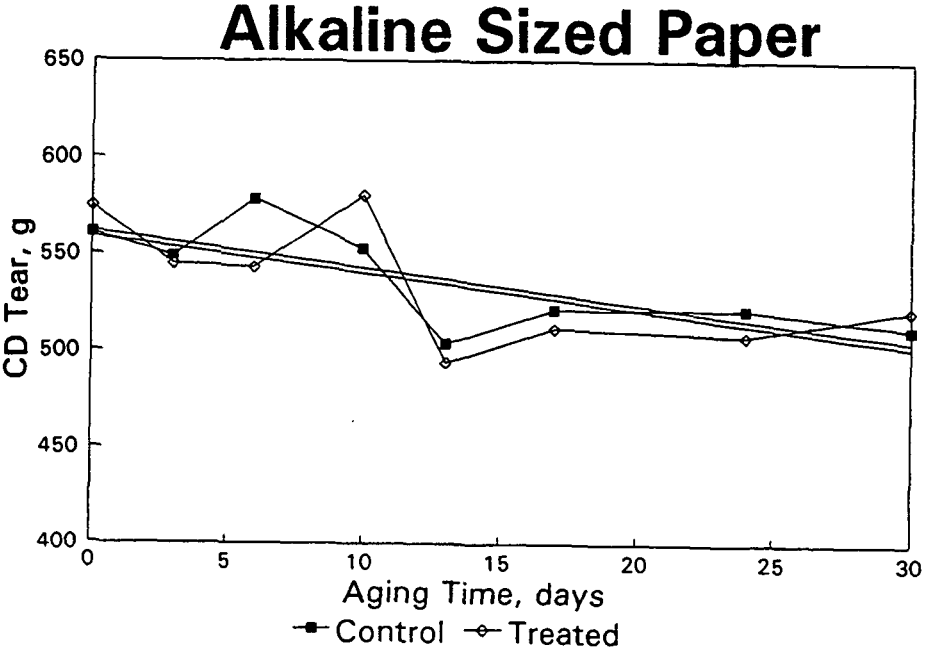

Fig.12-AS Affect of Aging Time on CD Tear Resistance.

TABLE XIII

MD ZERO-SPAN DATA (kN/m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	8.65	9.00	12.90	13.13	6.38	6.33	10.15	10.11
	Std Dev	0.45	0.42	0.35	0.10	0.11	0.36	0.46	0.43
3	Average	8.62	8.42	12.19	11.89	6.07	5.97	9.48	9.84
	Std Dev	0.51	0.51	0.51	0.62	0.27	0.31	0.25	0.41
6	Average	8.45	8.72	12.39	13.10	5.90	5.91	9.63	10.27
	Std Dev	0.42	0.59	0.56	0.31	0.48	0.31	0.49	0.49
10	Average	7.94	8.33	11.73	12.80	5.51	5.61	9.69	9.87
	Std Dev	0.41	0.33	0.26	0.16	0.21	0.23	0.38	0.23
13	Average	7.63	8.56	11.20	12.47	5.17	5.78	9.48	9.59
	Std Dev	0.56	0.43	0.33	0.39	0.31	0.43	0.56	0.52
17	Average	7.23	8.34	10.25	12.50	5.16	5.60	9.57	9.62
	Std Dev	0.46	0.47	0.51	0.46	0.34	0.27	0.50	0.50
24	Average	6.91	8.20	9.89	12.07	4.74	5.30	9.55	9.44
	Std Dev	0.48	0.37	0.45	0.24	0.21	0.33	0.39	0.33
30	Average	6.49	7.77	9.01	11.86	4.91	5.62	9.01	9.67
	Std Dev	0.28	0.29	0.50	0.22	0.17	0.21	0.54	0.47

REGRESSION STATISTICS

R Squared	0.977	0.768	0.970	0.379	0.873	0.659	0.573	0.529
Coefficient	-0.078	-0.031	-0.129	-0.030	-0.053	-0.024	-0.023	-0.020
Std Err	0.0049	0.0069	0.0092	0.0158	0.0082	0.0071	0.0080	0.0075
Constant	8.74	8.82	12.86	12.87	6.16	6.08	9.87	10.05

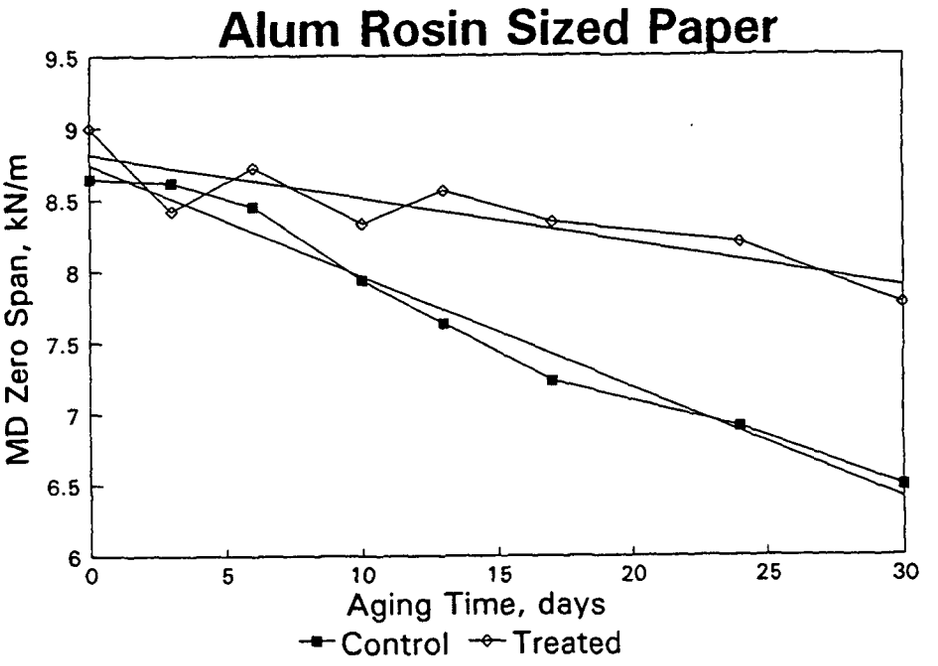

Fig.13-AR Affect of Aging Time on MD Zero-Span Tensile Strength.

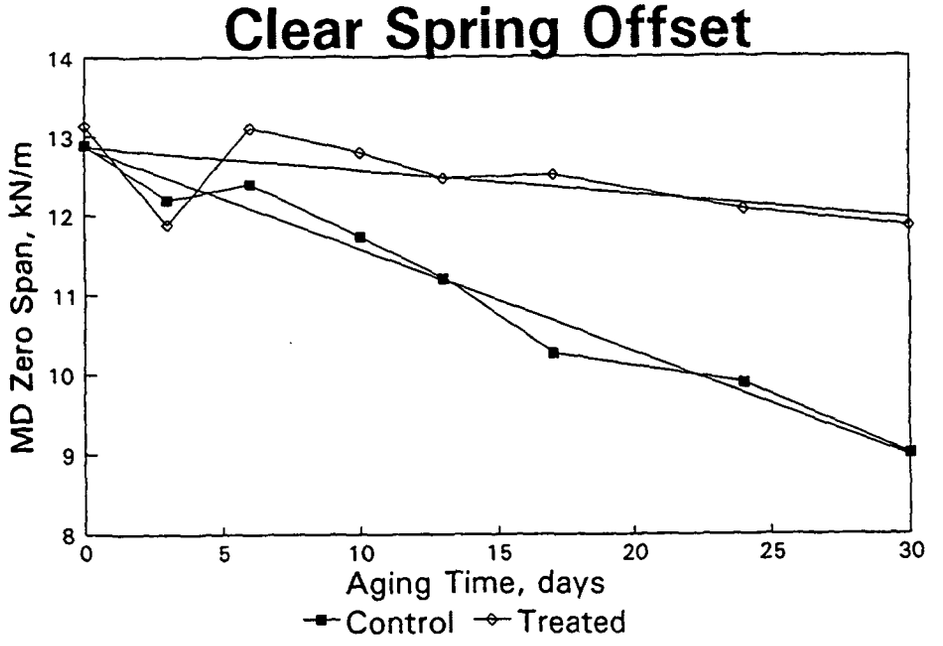

Fig.13-CS Affect of Aging Time on MD Zero-Span Tensile Strength.

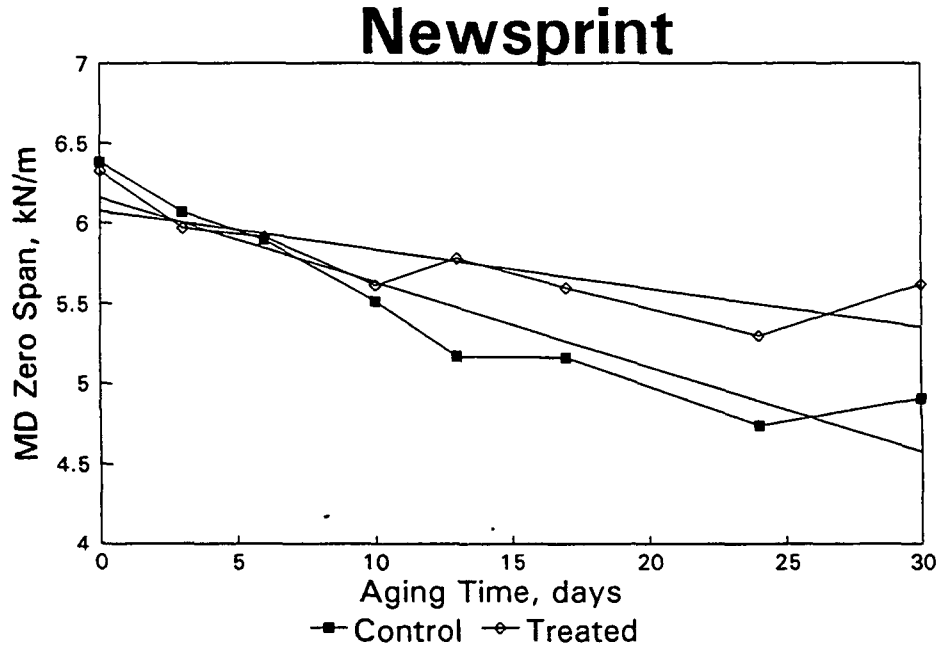

Fig.13-NP Affect of Aging Time on MD Zero-Span Tensile Strength.

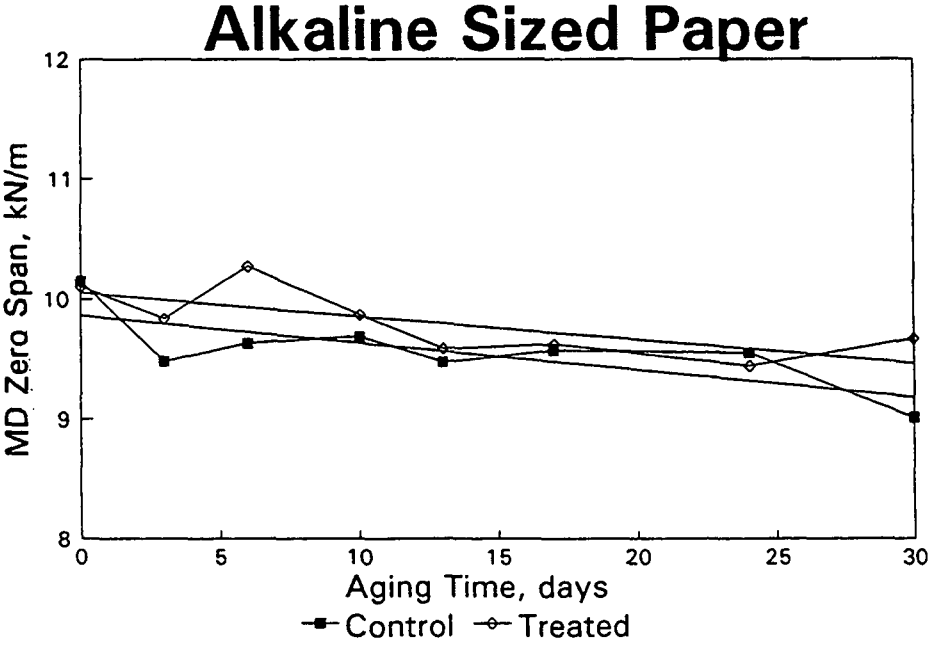

Fig.13-AS Affect of Aging Time on MD Zero-Span Tensile Strength.

TABLE XIV

CD ZERO-SPAN DATA (kN/m)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	5.39	5.17	8.46	7.95	2.92	2.83	8.40	8.95
	Std Dev	0.27	0.47	0.39	0.69	0.22	0.17	0.16	0.27
3	Average	5.38	5.16	7.51	8.21	2.84	3.09	8.62	9.16
	Std Dev	0.50	0.16	0.36	0.31	0.21	0.22	0.54	0.18
6	Average	4.63	4.69	7.14	7.79	2.59	2.75	7.87	8.59
	Std Dev	0.33	0.34	0.33	0.31	0.16	0.21	0.28	0.28
10	Average	4.61	4.90	6.74	7.79	2.61	2.83	8.16	8.22
	Std Dev	0.20	0.27	0.13	0.23	0.18	0.25	0.17	0.35
13	Average	4.59	4.96	6.92	7.48	2.51	2.84	8.54	8.89
	Std Dev	0.27	0.31	0.32	0.35	0.11	0.21	0.26	0.63
17	Average	4.50	4.94	6.17	7.42	2.47	2.51	8.22	8.63
	Std Dev	0.22	0.22	0.28	0.40	0.18	0.25	0.22	0.33
24	Average	4.04	4.79	5.59	7.08	2.28	2.46	8.50	8.19
	Std Dev	0.17	0.25	0.32	0.36	0.20	0.23	0.32	0.20
30	Average	3.96	4.69	5.77	7.34	2.16	2.45	8.43	8.87
	Std Dev	0.26	0.33	0.17	0.35	0.22	0.23	0.29	0.26

REGRESSION STATISTICS

R Squared	0.866	0.451	0.868	0.771	0.945	0.719	0.028	0.120
Coefficient	-0.047	-0.012	-0.085	-0.031	-0.024	-0.018	0.004	-0.012
Std Err	0.0076	0.0055	0.0136	0.0069	0.0024	0.0047	0.0096	0.0128
Constant	5.25	5.07	7.88	8.03	2.85	2.96	8.29	8.84

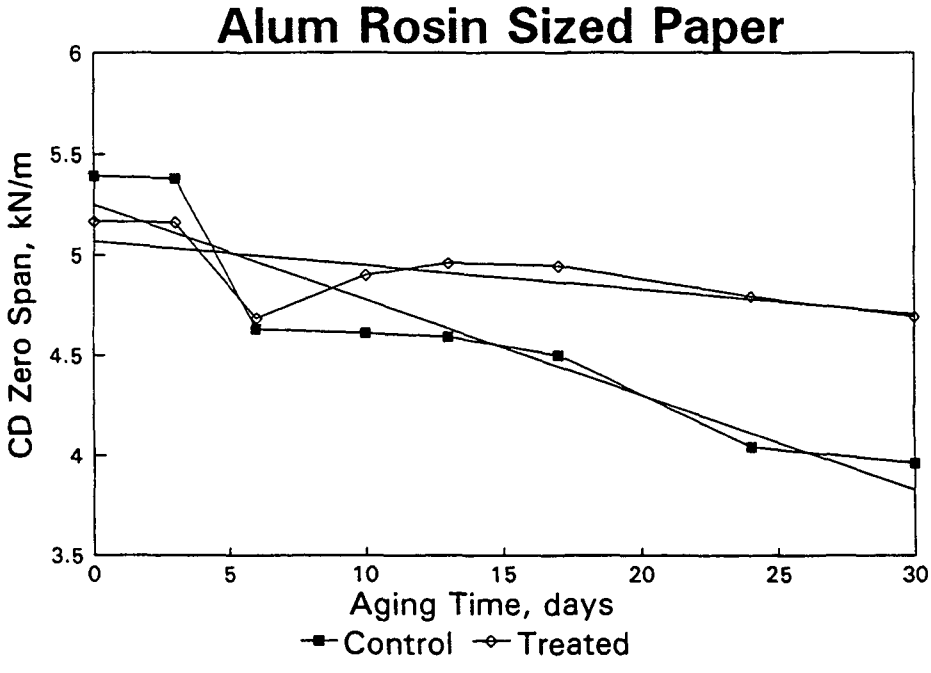

Fig.14-AR Affect of Aging Time on CD Zero-Span Tensile Strength.

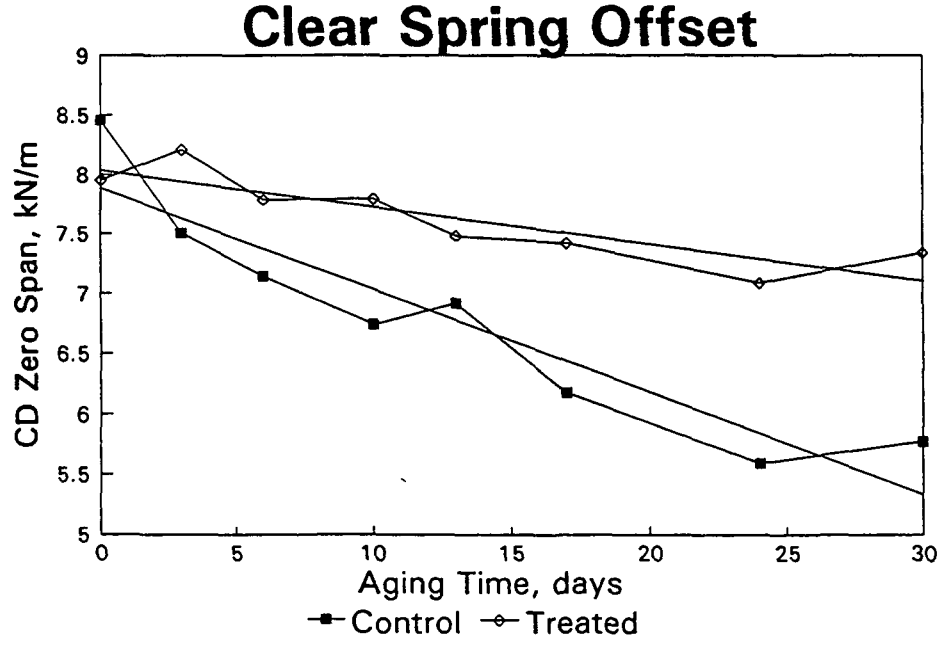

Fig.14-CS Affect of Aging Time on CD Zero-Span Tensile Strength.

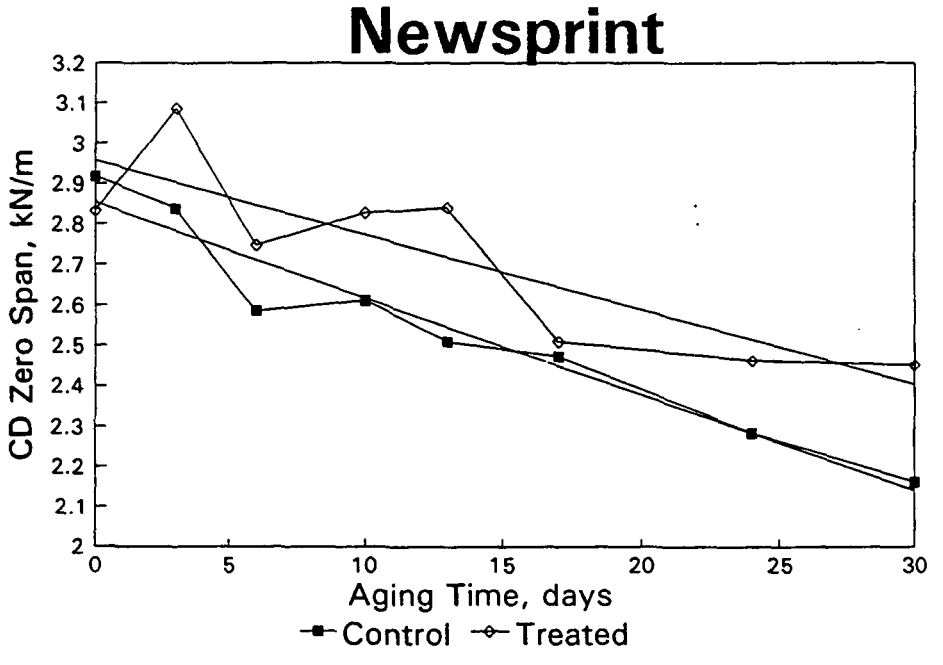

Fig.14-NP Affect of Aging Time on CD Zero-Span Tensile Strength.

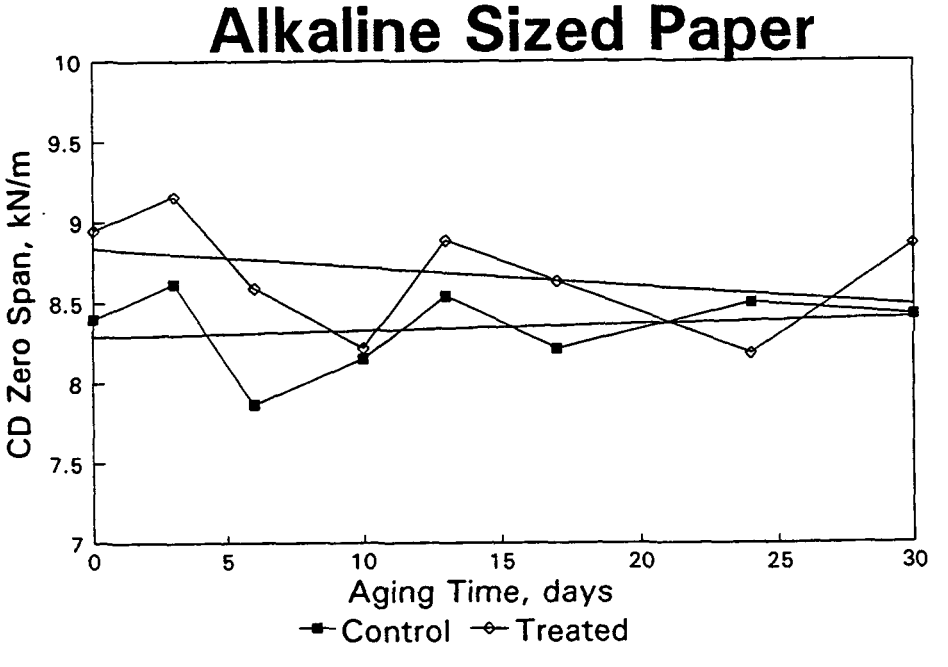

Fig.14-AS Affect of Aging Time on CD Zero-Span Tensile Strength.

TABLE XV

OPACITY DATA (%)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	85.9	88.9	93.1	94.3	88.3	88.6	94.0	94.1
	Std Dev	0.7	0.5	0.3	0.5	0.7	0.4	0.2	0.1
3	Average	87.7	88.9	94.1	94.2	89.6	90.2	94.1	94.4
	Std Dev	1.3	1.0	0.6	0.3	0.9	0.5	0.3	0.3
6	Average	89.3	89.0	93.5	93.8	90.8	90.5	93.7	94.0
	Std Dev	0.8	0.6	0.3	0.5	0.6	0.7	0.2	0.4
10	Average	87.8	90.1	94.1	94.1	90.8	90.7	94.0	94.4
	Std Dev	1.2	0.7	0.6	0.5	0.8	0.6	0.2	0.4
13	Average	89.4	90.8	94.4	95.1	91.4	92.0	94.2	94.0
	Std Dev	0.8	0.5	0.5	0.3	0.5	0.5	0.3	0.3
17	Average	88.1	90.8	94.7	94.0	92.9	90.4	94.1	94.8
	Std Dev	1.2	0.4	0.3	0.4	0.3	1.0	0.3	0.2
24	Average	90.8	91.0	95.3	95.2	91.4	91.9	94.6	95.4
	Std Dev	1.4	0.5	0.3	0.2	0.4	0.3	0.4	0.2
30	Average	91.7	92.3	95.1	95.3	92.4	93.3	95.1	95.4
	Std Dev	0.8	0.5	0.3	0.3	0.5	0.3	0.2	0.2

REGRESSION STATISTICS

R Squared	0.755	0.922	0.824	0.537	0.667	0.769	0.749	0.738
Coefficient	0.153	0.113	0.066	0.043	0.117	0.120	0.037	0.048
Std Err	0.0357	0.0134	0.0124	0.0163	0.0338	0.0269	0.0088	0.1169
Constant	86.9	88.8	93.4	93.9	89.4	89.4	93.8	93.9

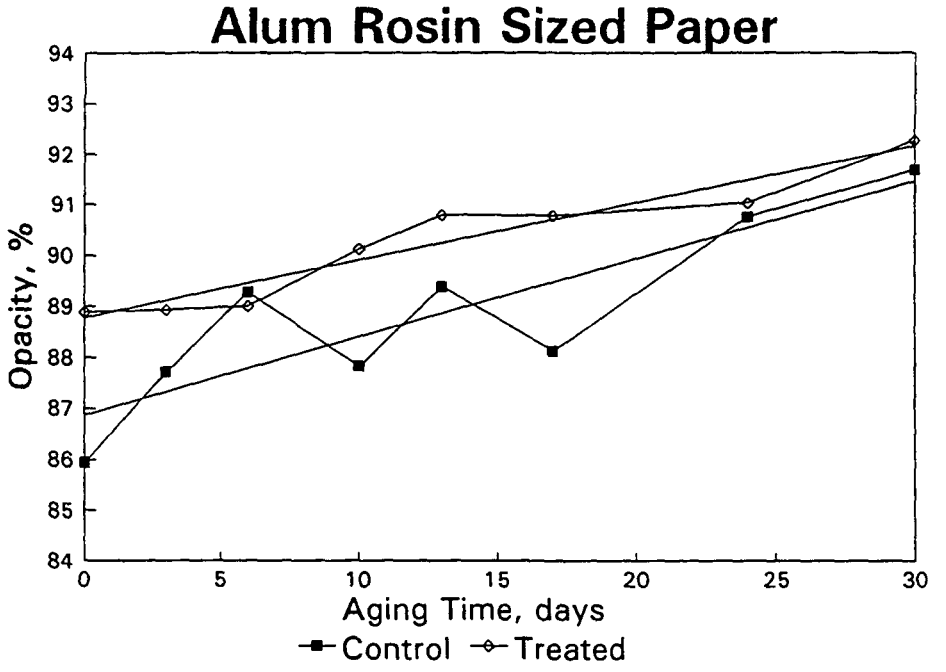

Fig.15-AR Affect of Aging Time on Opacity.

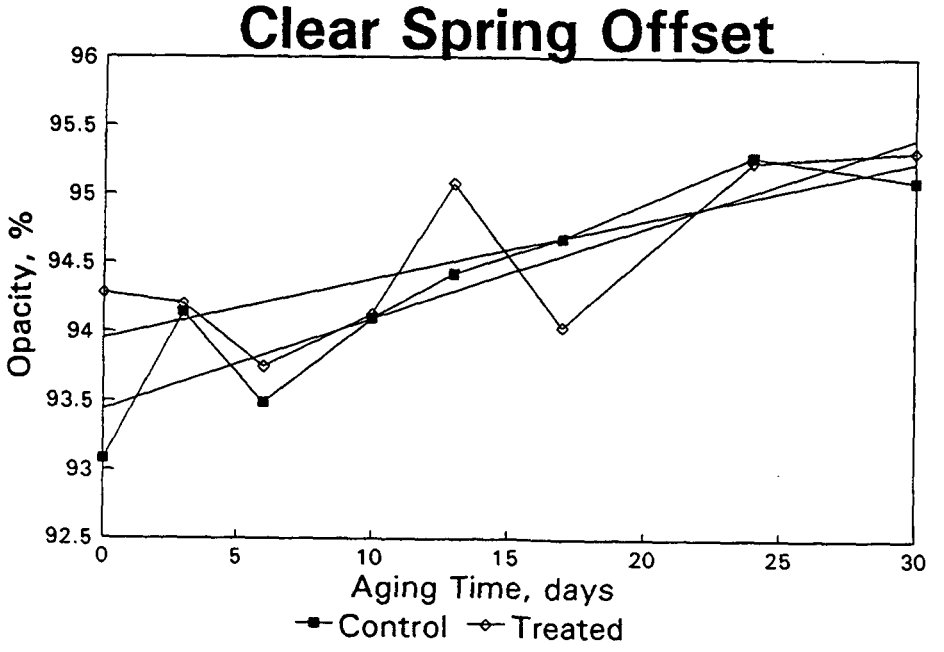

Fig.15-CS Affect of Aging Time on Opacity.

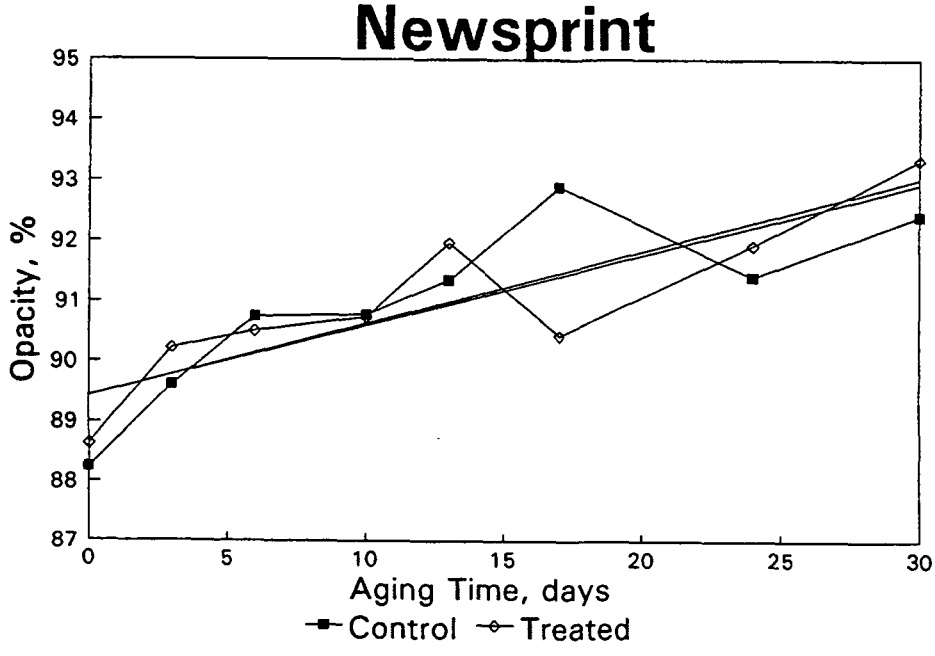

Fig.15-NP Affect of Aging Time on Opacity.

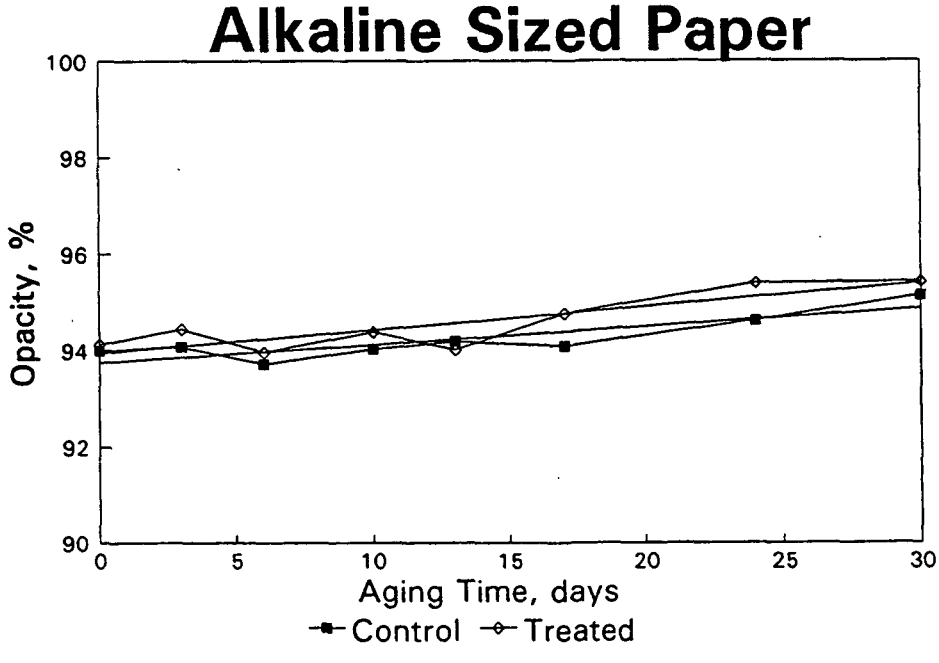

Fig.15-AS Affect of Aging Time on Opacity.

TABLE XVI

BRIGHTNESS DATA (%)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	79.4	80.3	77.8	78.6	45.2	46.8	86.5	85.4
	Std Dev	0.5	0.1	0.1	0.5	1.0	0.6	3.2	0.2
3	Average	74.5	74.7	74.7	75.8	40.5	42.2	84.6	83.3
	Std Dev	0.2	0.7	0.1	0.2	0.9	0.3	3.2	0.3
6	Average	72.2	72.9	72.7	74.2	38.3	39.2	82.6	82.2
	Std Dev	0.7	0.5	0.4	0.3	0.6	0.9	0.1	0.4
10	Average	69.5	70.0	69.7	71.8	34.7	38.0	81.8	80.9
	Std Dev	0.4	0.7	0.5	0.3	0.9	1.2	0.1	0.6
13	Average	67.1	66.9	68.1	70.6	33.8	36.5	81.1	80.0
	Std Dev	0.6	0.8	0.2	0.3	1.5	0.9	0.1	0.1
17	Average	64.8	66.2	65.6	68.8	31.3	33.5	80.1	79.7
	Std Dev	1.2	0.9	0.5	0.5	1.3	0.7	0.1	1.2
24	Average	60.8	62.8	60.8	65.5	30.4	32.0	77.3	75.6
	Std Dev	0.6	1.2	0.3	0.5	1.1	0.8	0.6	1.0
30	Average	61.2	60.9	58.6	64.8	28.2	30.9	77.1	75.5
	Std Dev	0.9	0.9	0.3	0.5	1.3	1.1	0.1	0.4

REGRESSION STATISTICS

R Squared	0.920	0.926	0.990	0.964	0.891	0.900	0.948	0.960
Coefficient	-0.602	-0.598	-0.638	-0.458	-0.518	-0.491	-0.307	-0.326
Std Err	0.0724	0.0688	0.0268	0.0361	0.0739	0.0667	0.0294	0.0272
Constant	76.4	77.0	76.7	77.1	42.0	43.7	85.3	84.5

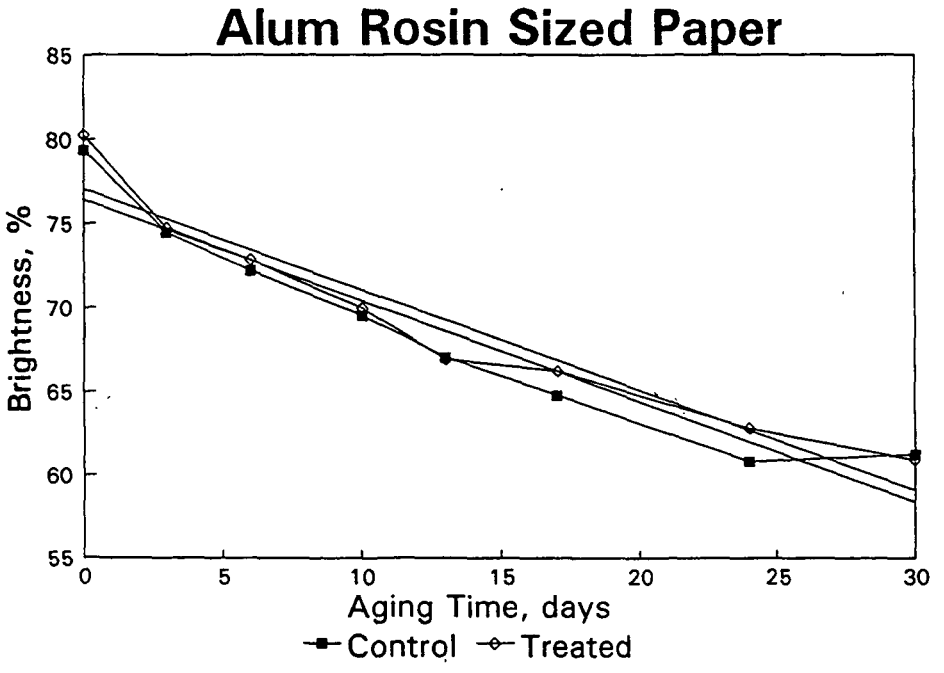

Fig.16-AR Affect of Aging Time on Brightness.

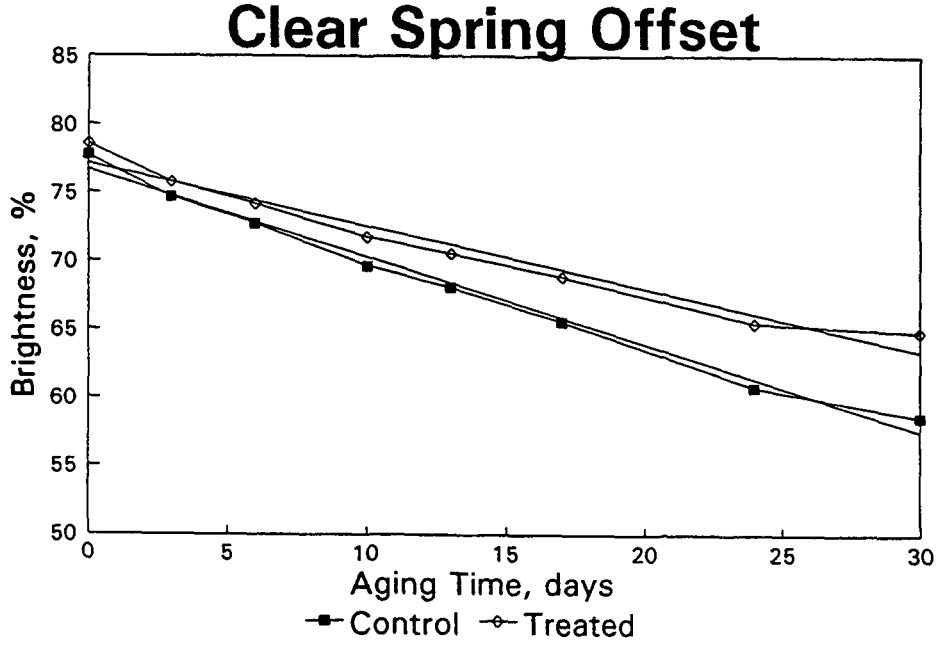

Fig.16-CS Affect of Aging Time on Brightness.

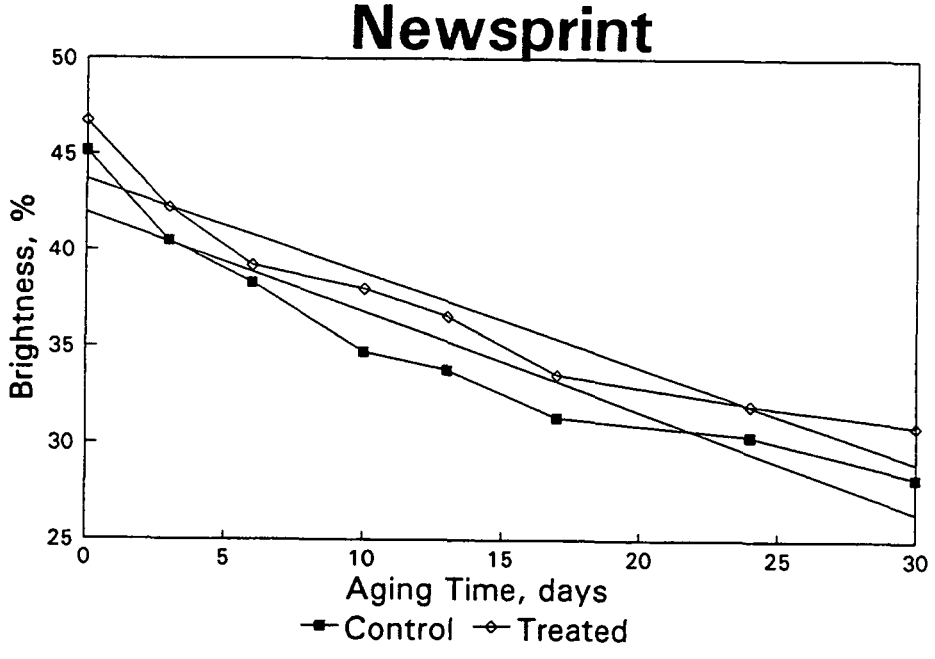

Fig.16-NP Affect of Aging Time on Brightness.

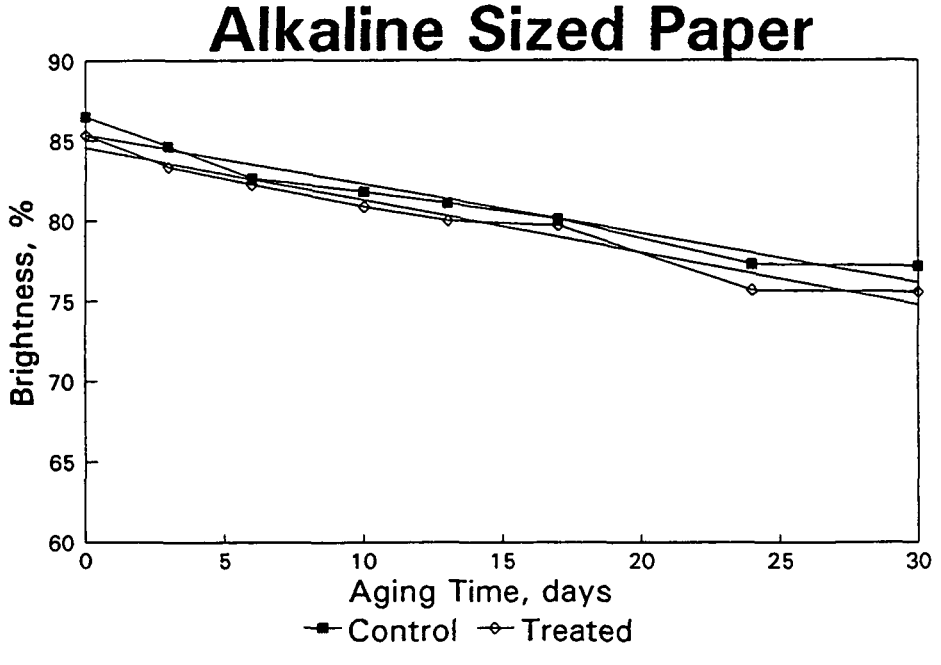

Fig.16-AS Affect of Aging Time on Brightness.

TABLE XVII

COLOR DATA (L)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	90.6	91.0	89.8	90.3	74.8	75.2	95.2	95.1
	Std Dev	0.2	0.0	0.0	0.1	0.2	0.3	0.1	0.1
3	Average	89.5	89.6	89.3	89.7	72.2	73.2	94.5	94.2
	Std Dev	0.1	0.2	0.1	0.1	0.5	0.2	0.1	1.0
6	Average	88.6	89.0	88.6	89.2	71.3	71.8	94.0	94.0
	Std Dev	0.2	0.1	0.1	0.1	0.4	0.5	0.0	0.1
10	Average	87.9	88.2	87.8	88.6	69.5	71.4	93.8	93.6
	Std Dev	0.2	0.2	0.2	0.1	0.7	0.7	0.0	0.1
13	Average	87.1	87.2	87.3	88.2	68.8	70.7	93.6	93.3
	Std Dev	0.2	0.3	0.1	0.1	1.1	0.6	0.0	0.0
17	Average	86.2	86.9	87.5	87.8	67.7	69.1	93.2	93.1
	Std Dev	0.4	0.3	3.2	0.2	1.0	0.5	0.1	0.3
24	Average	84.9	85.7	84.8	86.8	67.2	68.3	92.4	91.9
	Std Dev	0.2	0.5	0.1	0.3	0.9	0.7	0.2	0.3
30	Average	85.0	85.1	84.0	86.5	65.9	67.8	92.2	91.8
	Std Dev	0.3	0.3	0.1	0.2	1.2	1.0	0.1	0.1

REGRESSION STATISTICS

R Squared	0.946	0.957	0.962	0.978	0.894	0.913	0.966	0.953
Coefficient	-0.193	-0.187	-0.193	-0.126	-0.267	-0.231	-0.096	-0.106
Std Err	0.0188	0.0161	0.0156	0.0076	0.0375	0.0291	0.0074	0.0096
Constant	89.9	90.2	89.9	90.0	73.1	73.9	94.8	94.7

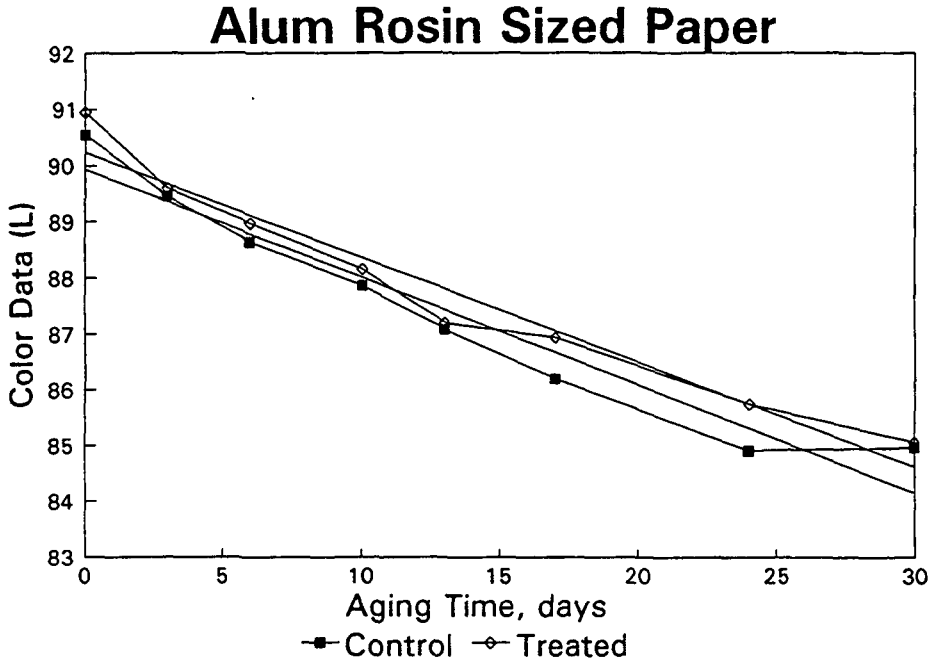

Fig.17-AR Affect of Aging Time on Color (L).

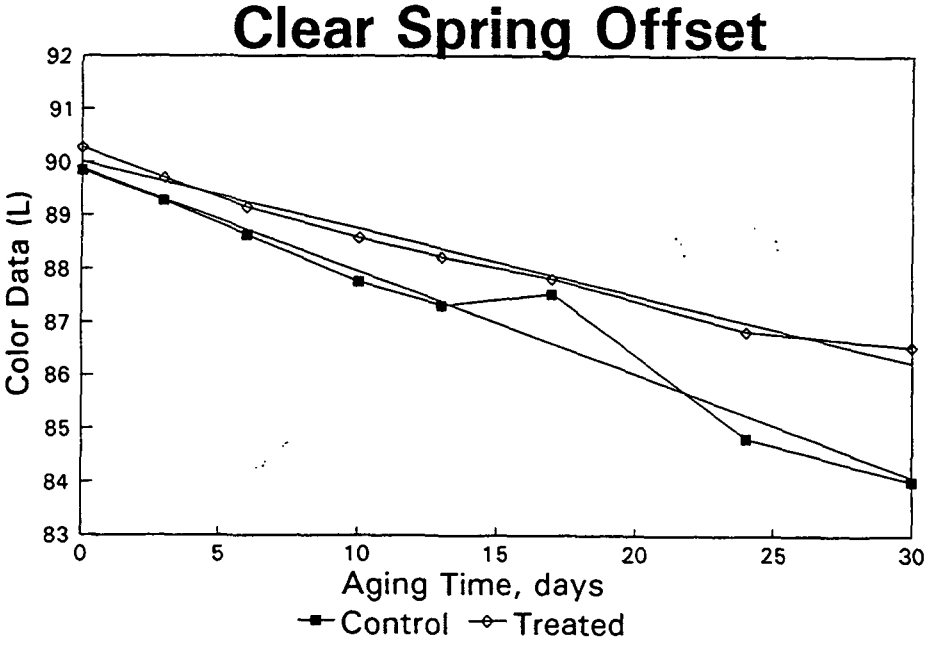

Fig.17-CS Affect of Aging Time on Color (L).

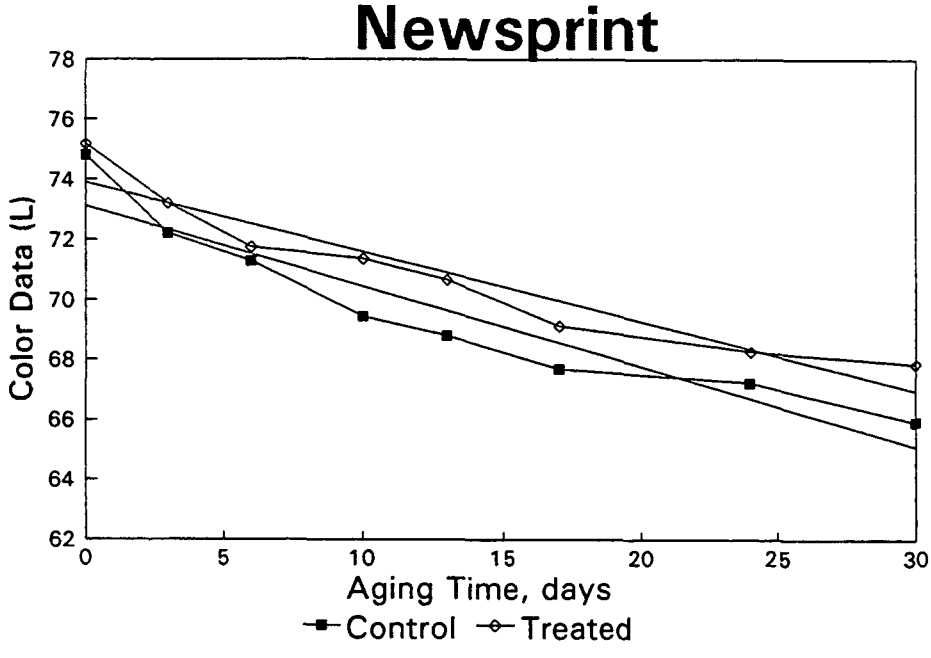

Fig.17-NP Affect of Aging Time on Color (L).

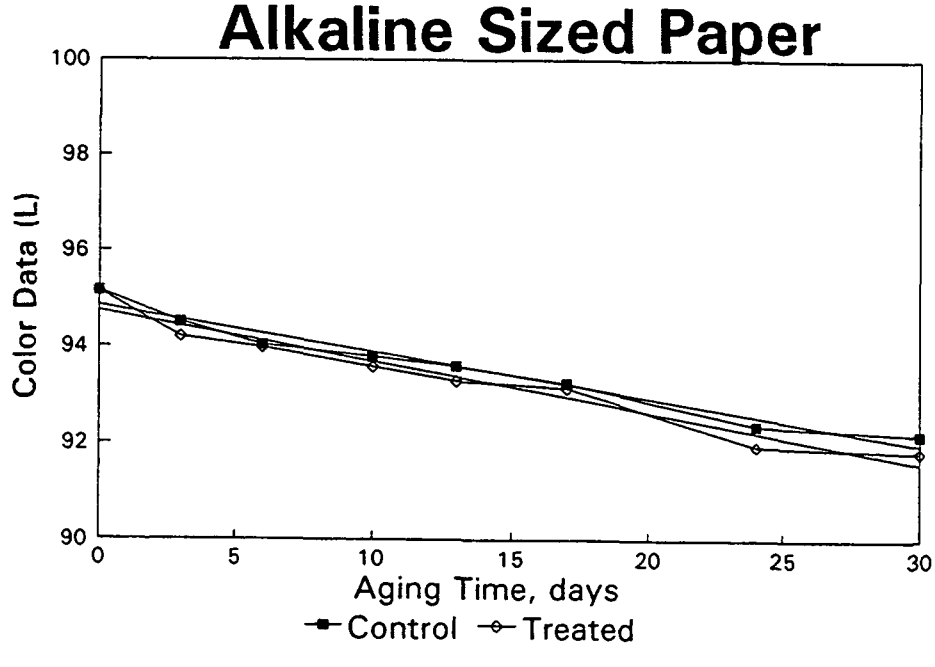

Fig.17-AS Affect of Aging Time on Color (L).

TABLE XVIII

COLOR DATA (a)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	0.30	0.35	-0.04	-0.02	2.09	1.94	-0.31	-0.27
	Std Dev	0.07	0.06	0.06	0.25	0.11	0.13	0.04	0.04
3	Average	0.38	0.29	0.25	0.13	3.20	2.79	-0.16	-0.18
	Std Dev	0.03	0.08	0.11	0.05	0.11	0.15	0.04	0.03
6	Average	0.87	0.85	0.96	0.73	4.20	3.86	0.46	0.43
	Std Dev	0.05	0.09	0.09	0.22	0.15	0.16	0.03	0.04
10	Average	1.02	0.92	1.20	1.01	4.69	4.04	0.53	0.51
	Std Dev	0.05	0.07	0.10	0.10	0.28	0.28	0.03	0.03
13	Average	1.06	0.91	1.30	0.98	4.86	3.99	0.57	0.49
	Std Dev	0.06	0.07	0.10	0.10	0.45	0.21	0.04	0.04
17	Average	1.19	0.96	1.46	0.91	5.27	4.57	0.62	0.59
	Std Dev	0.08	0.05	0.09	0.17	0.28	0.16	0.04	0.06
24	Average	1.30	1.07	1.56	1.01	5.54	4.73	0.57	0.54
	Std Dev	0.08	0.05	0.07	0.16	0.22	0.26	0.10	0.06
30	Average	1.42	1.23	1.84	1.25	5.84	4.87	0.76	0.70
	Std Dev	0.05	0.07	0.10	0.15	0.22	0.25	0.05	0.08

REGRESSION STATISTICS

R Squared	0.843	0.777	0.828	0.699	0.818	0.777	0.647	0.648
Coefficient	0.036	0.028	0.057	0.036	0.110	0.086	0.030	0.028
Std Err	0.0064	0.0061	0.0106	0.0098	0.0212	0.0188	0.0091	0.0085
Constant	0.47	0.46	0.33	0.28	3.04	2.74	-0.01	-0.01

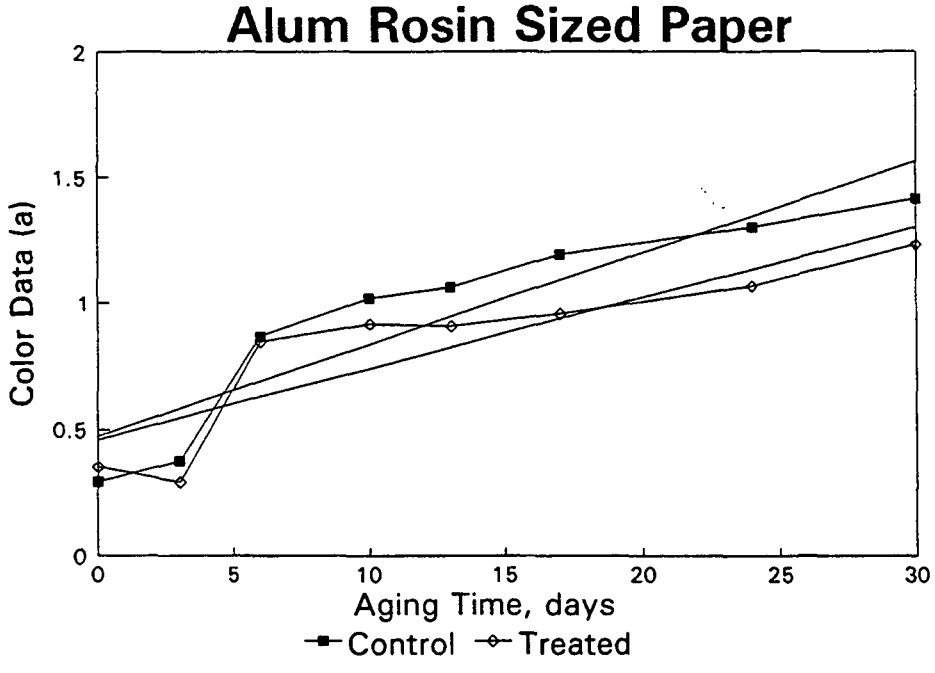

Fig.18-AR Affect of Aging Time on Color (a).

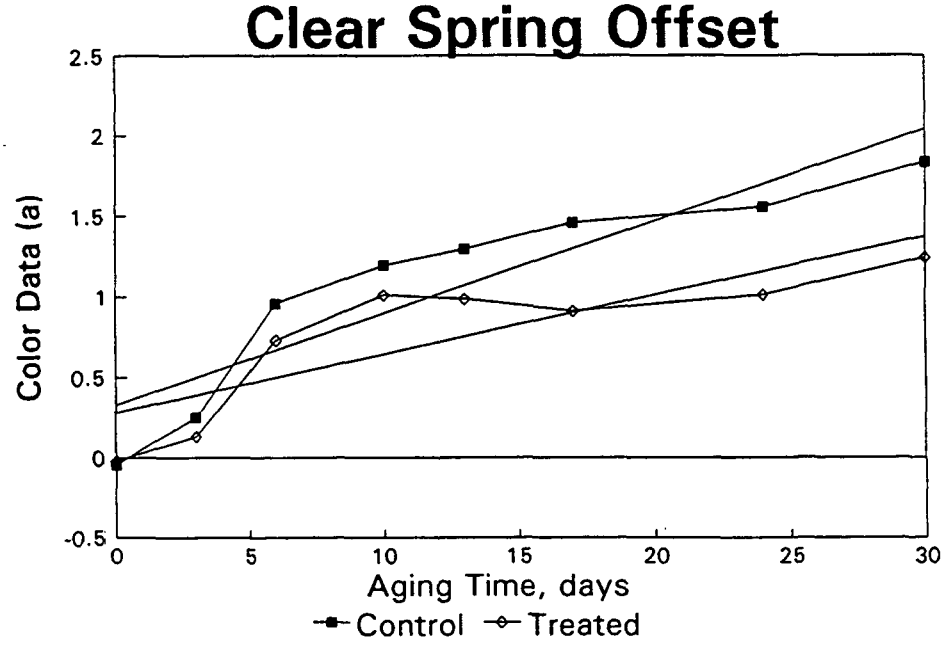

Fig.18-CS Affect of Aging Time on Color (a).

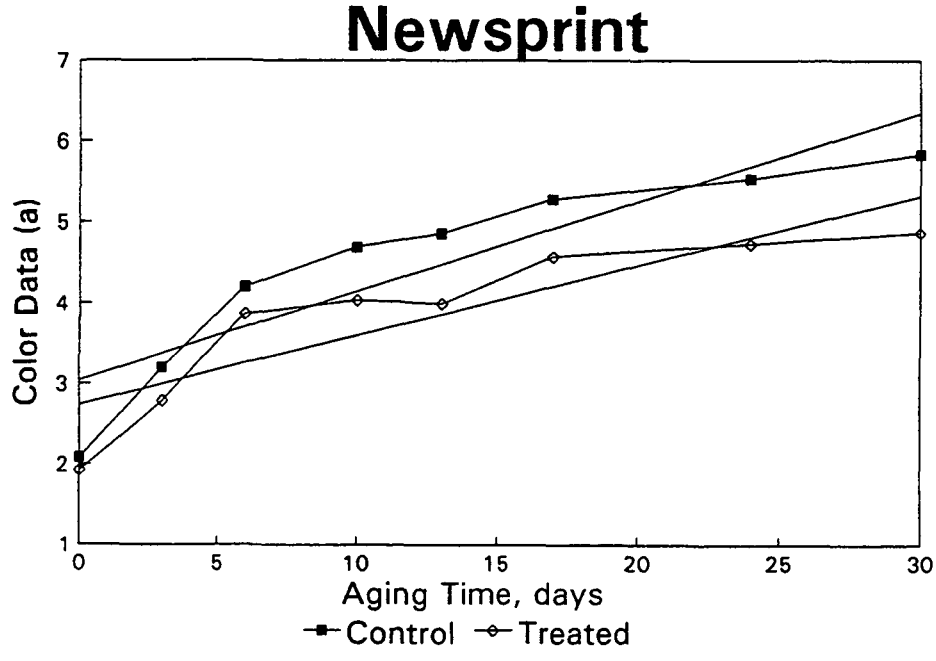

Fig.18-NP Affect of Aging Time on Color (a).

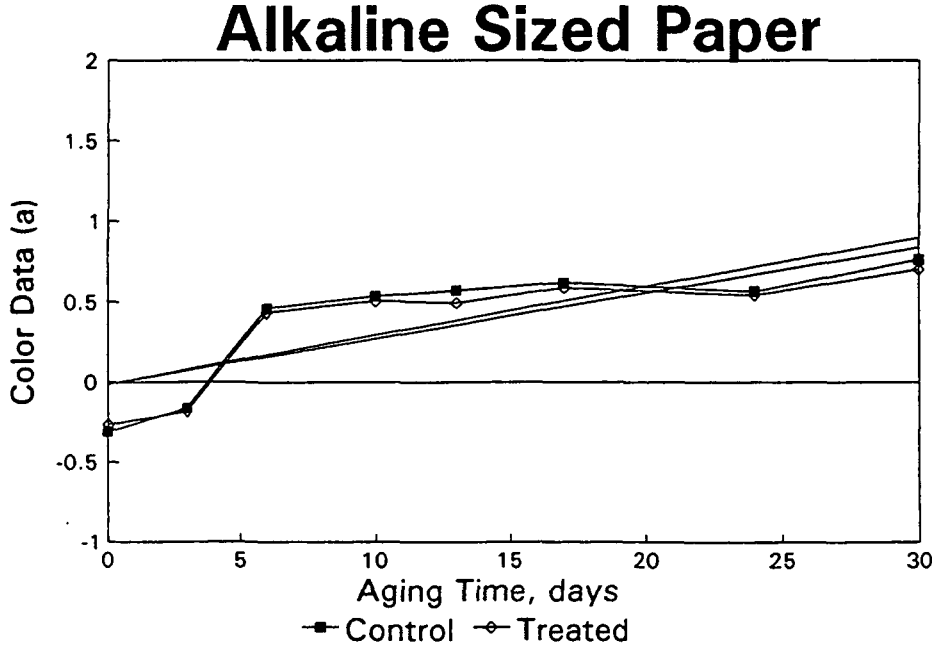

Fig.18-AS Affect of Aging Time on Color (a).

TABLE XIX

COLOR DATA (b)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	2.19	2.07	2.83	2.78	10.76	9.76	4.25	4.28
	Std Dev	0.19	0.08	0.04	0.21	0.80	0.14	0.04	0.07
3	Average	4.62	4.60	4.46	4.19	11.87	11.45	4.70	4.94
	Std Dev	0.06	0.30	0.03	0.04	0.38	0.12	0.05	0.10
6	Average	5.31	5.34	5.18	4.77	12.89	12.65	4.86	5.05
	Std Dev	0.21	0.23	0.18	0.08	0.11	0.33	0.03	0.14
10	Average	6.50	6.51	6.43	5.84	14.26	13.32	5.12	5.54
	Std Dev	0.12	0.33	0.21	0.05	0.15	0.41	0.04	0.24
13	Average	7.48	7.75	7.16	6.37	14.40	13.91	5.37	5.85
	Std Dev	0.22	0.33	0.08	0.09	0.28	0.30	0.03	0.02
17	Average	8.17	7.94	8.08	7.17	15.56	15.03	5.67	5.92
	Std Dev	0.46	0.31	0.14	0.18	0.10	0.10	0.07	0.42
24	Average	9.77	9.33	9.81	8.60	16.02	15.63	6.65	7.36
	Std Dev	0.23	0.46	0.11	0.15	0.26	0.10	0.19	0.42
30	Average	9.54	9.95	10.48	8.75	16.67	16.17	6.50	7.26
	Std Dev	0.34	0.33	0.06	0.19	0.11	0.06	0.03	0.21

REGRESSION STATISTICS

R Squared	0.894	0.903	0.973	0.954	0.919	0.909	0.953	0.949
Coefficient	0.236	0.239	0.250	0.198	0.192	0.200	0.080	0.102
Std Err	0.0331	0.0320	0.0170	0.0179	0.0233	0.0258	0.0073	0.0096
Constant	3.66	3.60	3.58	3.51	11.58	10.91	4.36	4.46

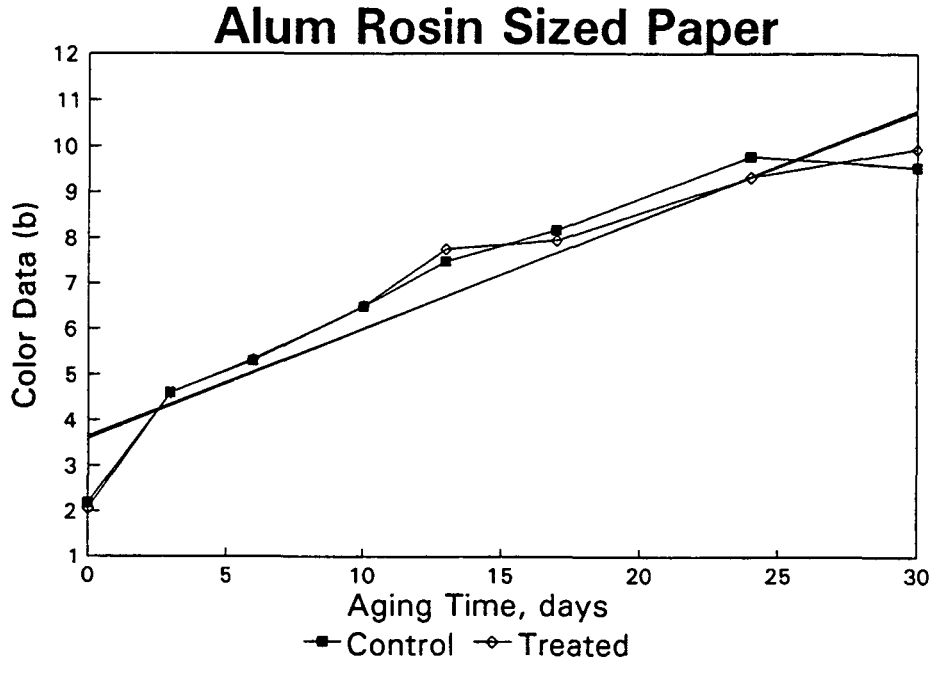

Fig.19-AR Affect of Aging Time on Color (b).

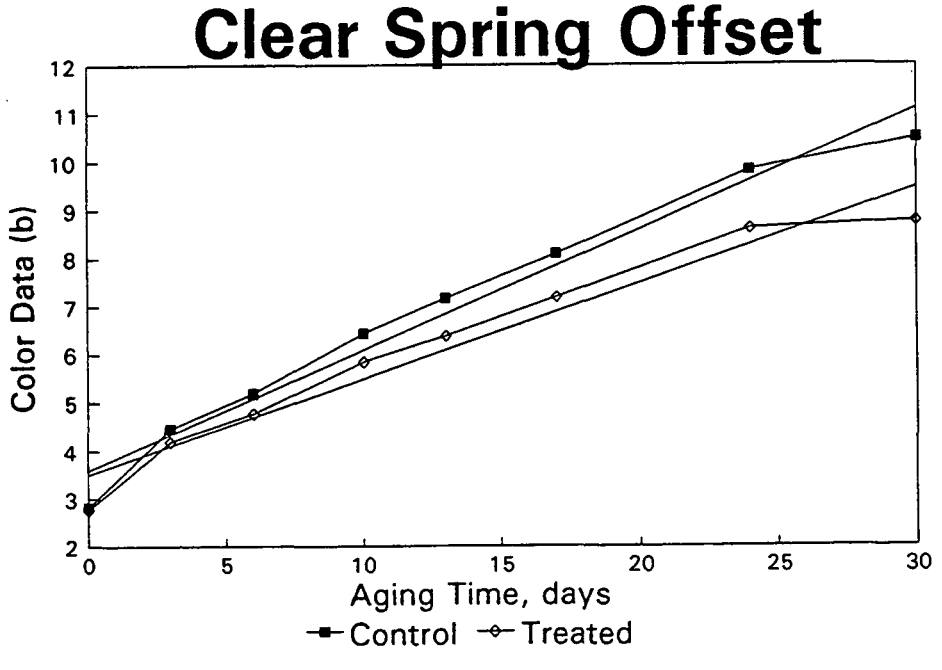

Fig.19-CS Affect of Aging Time on Color (b).

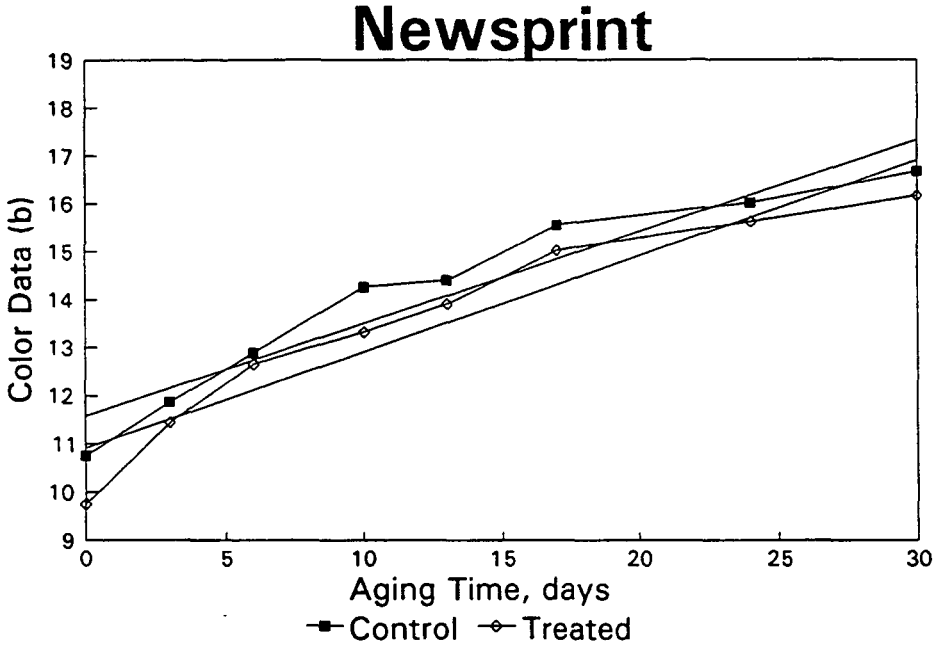

Fig.19-NP Affect of Aging Time on Color (b).

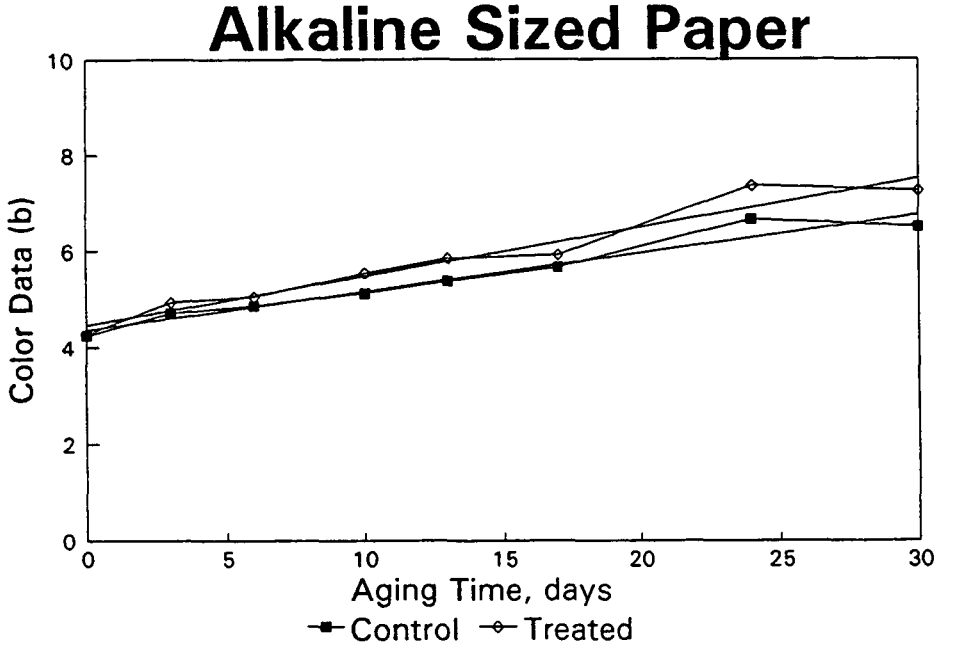

Fig.19-AS Affect of Aging Time on Color (b).

TABLE XX

HYDROGEN ION CONCENTRATION (pH)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	6.52	9.32	5.88	9.10	5.70	10.27	9.42	10.50
	Range	0.03	0.03	0.08	0.12	0.12	0.12	0.04	0.09
3	Average	6.35	8.79	5.62	8.87	5.28	10.03	9.18	9.99
	Range	0.02	0.07	0.08	0.09	0.01	0.00	0.03	0.03
6	Average	5.64	8.44	5.12	8.29	4.67	9.57	8.87	9.67
	Range	0.03	0.03	0.03	0.25	0.02	0.06	0.04	0.02
10	Average	5.80	8.33	4.65	8.21	4.52	9.45	8.84	9.72
	Range	0.07	0.05	0.07	0.13	0.12	0.03	0.06	0.03
13	Average	5.59	8.20	4.81	8.00	4.28	9.48	8.85	9.58
	Range	0.02	0.03	0.04	0.04	0.01	0.01	0.02	0.01
17	Average	5.75	8.13	4.65	7.89	4.30	9.34	8.75	9.50
	Range	0.00	0.02	0.08	0.09	0.05	0.01	0.05	0.07
24	Average	5.60	8.00	4.63	7.80	4.08	9.37	8.94	9.56
	Range	0.01	0.04	0.00	0.02	0.02	0.01	0.00	0.02
30	Average	5.64	8.01	4.65	7.75	4.16	9.31	8.67	9.63
	Range	0.03	0.01	0.01	0.09	0.02	0.05	0.01	0.05

REGRESSION STATISTICS

R Squared	0.501	0.727	0.642	0.788	0.725	0.655	0.549	0.475
Coefficient	-0.025	-0.037	-0.038	-0.043	-0.047	-0.028	-0.017	-0.022
Std Err	0.0101	0.0093	0.0117	0.0091	0.0119	0.0082	0.0065	0.0094
Constant	6.18	8.88	5.49	8.79	5.23	9.96	9.16	10.05

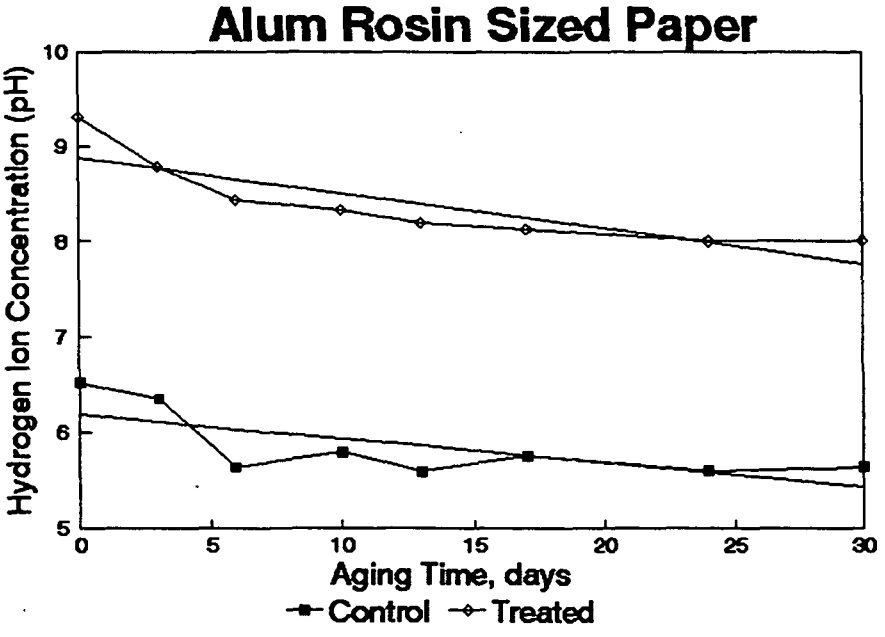

Fig.20-AR Affect of Aging Time on Hydrogen ion Concentration (pH).

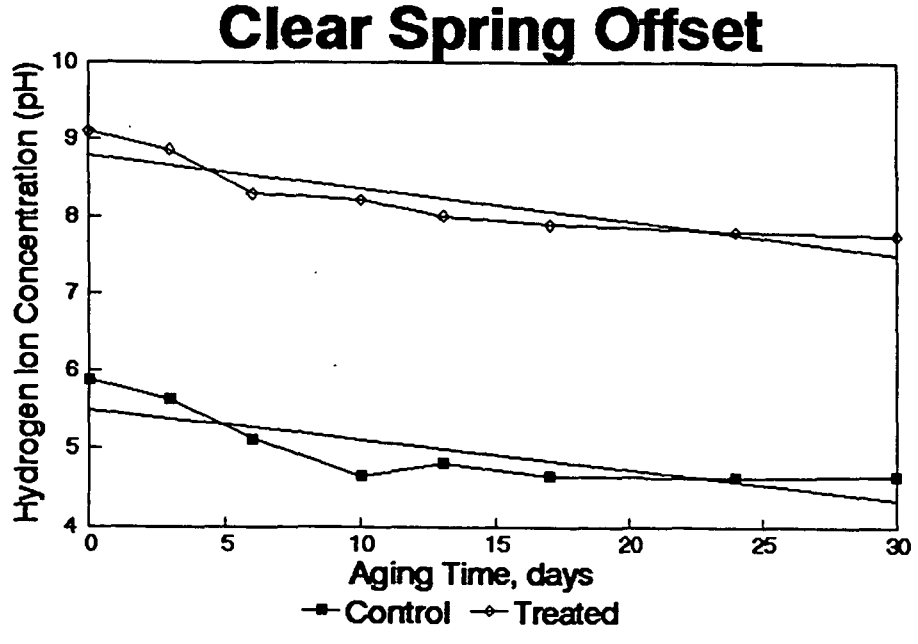

Fig.20-CS Affect of Aging Time on Hydrogen ion Concentration (pH).

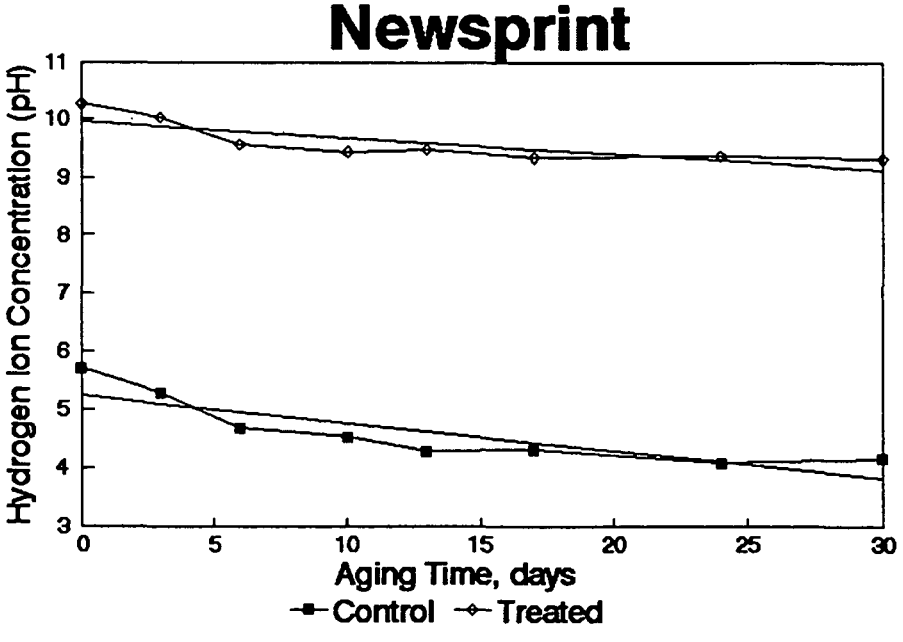

Fig.20-NP Affect of Aging Time on Hydrogen ion Concentration (pH).

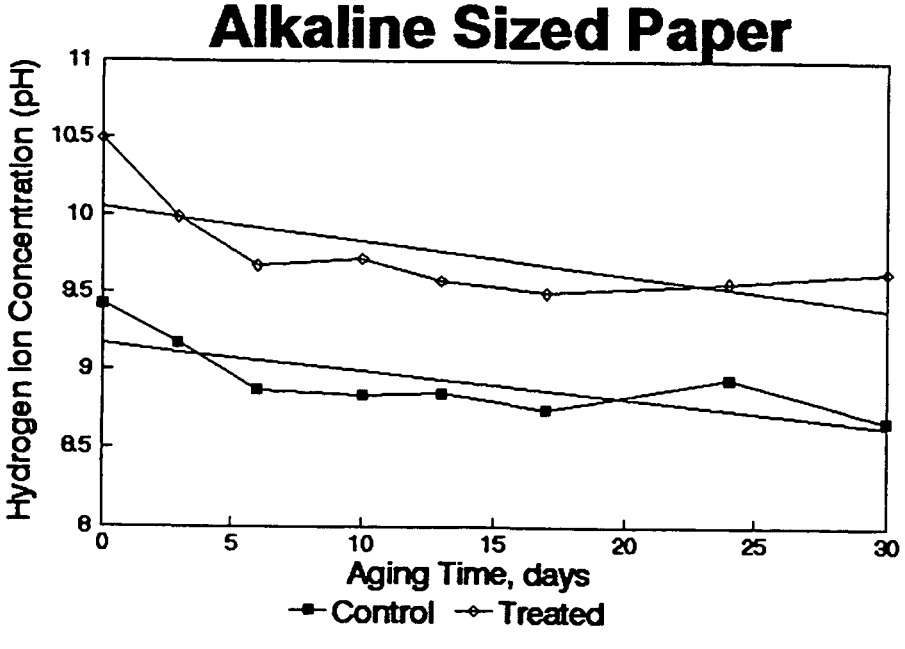

Fig.20-AS Affect of Aging Time on Hydrogen ion Concentration (pH).

TABLE XXI

ALKALINE RESERVE DATA (% CaCO3)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	0.52	0.71	0.00	0.63	0.14	0.72	8.21	8.50
	Range	0.01	0.15	0.00	0.11	0.05	0.13	0.19	0.10
3	Average	0.45	1.33	0.08	0.73	0.00	0.95	7.97	8.46
	Range	0.05	0.06	0.16	0.10	0.00	0.01	0.33	0.06
6	Average	0.42	1.12	0.11	0.54	0.00	0.86	8.09	8.33
	Range	0.01	0.17	0.11	0.05	0.00	0.06	0.05	0.01
10	Average	0.49	1.15	0.08	0.57	0.03	0.97	8.23	8.48
	Range	0.05	0.06	0.05	0.09	0.05	0.15	0.11	0.00
13	Average	0.52	1.28	0.37	0.65	0.00	1.29	8.13	8.86
	Range	0.00	0.05	0.11	0.06	0.00	0.14	0.06	0.11
17	Average	0.47	1.10	0.05	0.71	0.00	1.08	8.00	8.57
	Range	0.11	0.11	0.10	0.05	0.00	0.05	0.00	0.13
24	Average	0.49	1.29	0.10	0.86	0.08	0.86	8.11	8.76
	Range	0.04	0.10	0.10	0.05	0.05	0.06	0.12	0.04
30	Average	0.60	1.30	0.24	0.78	0.00	1.02	8.04	8.80
	Range	0.05	0.02	0.05	0.00	0.00	0.13	0.06	0.07

REGRESSION STATISTICS

R Squared	0.360	0.299	0.191	0.455	0.062	0.125	0.057	0.529
Coefficient	0.003	0.011	0.005	0.007	-0.001	0.006	-0.002	0.013
Std Err	0.0018	0.0067	0.0042	0.0032	0.0019	0.0063	0.0035	0.0051
Constant	0.45	1.02	0.06	0.59	0.05	0.89	8.12	8.42

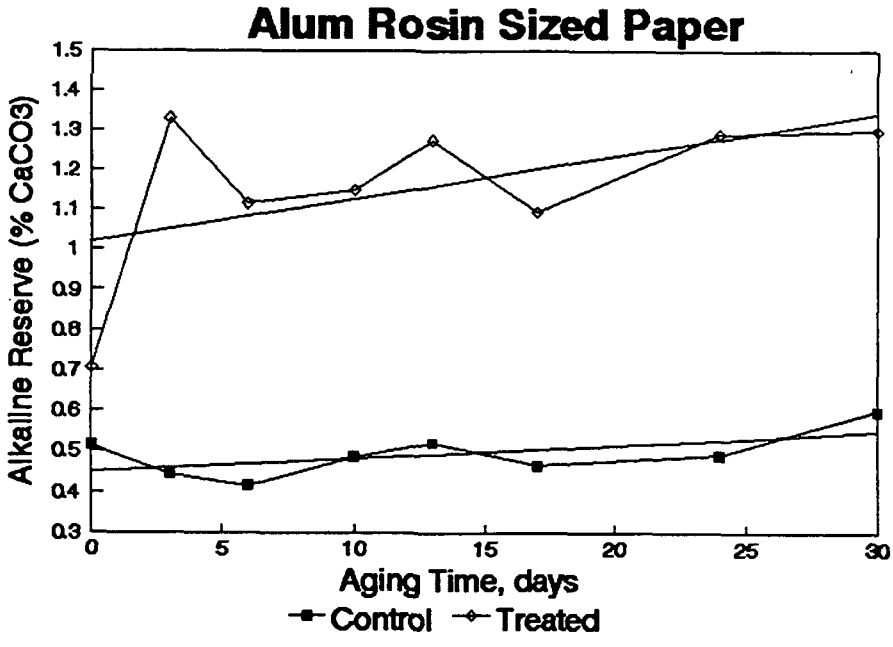

Fig.21-AR Affect of Aging Time on Alkaline Reserve (% CaCO3).

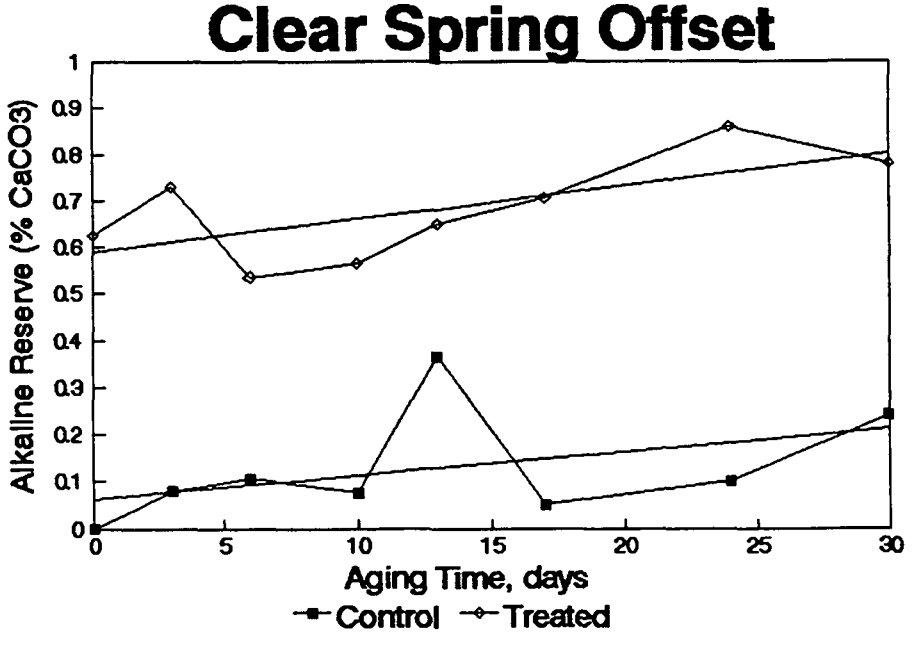

Fig.21-CS Affect of Aging Time on Alkaline Reserve (% CaCO3).

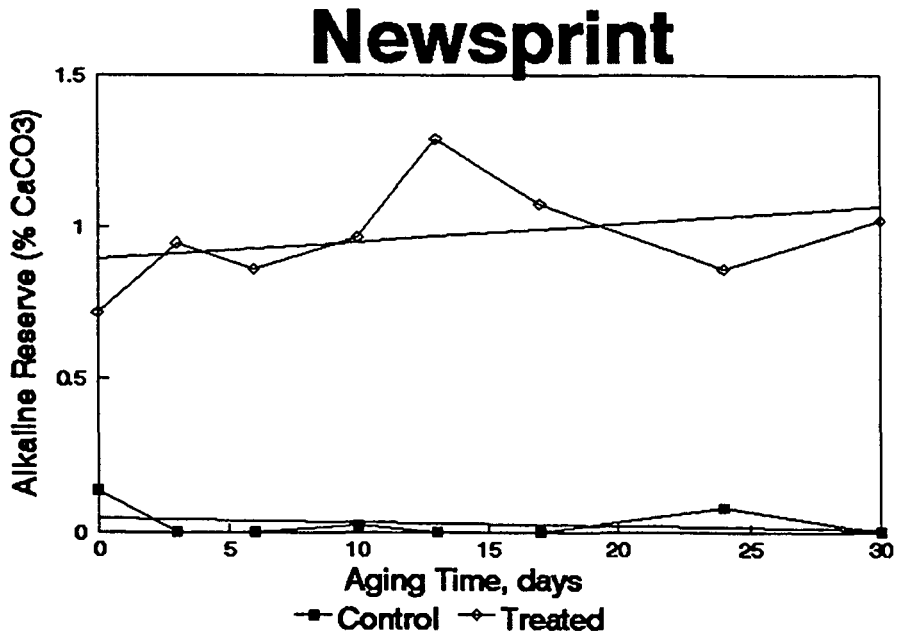

Fig.21-NP Affect of Aging Time on Alkaline Reserve (% CaCO3).

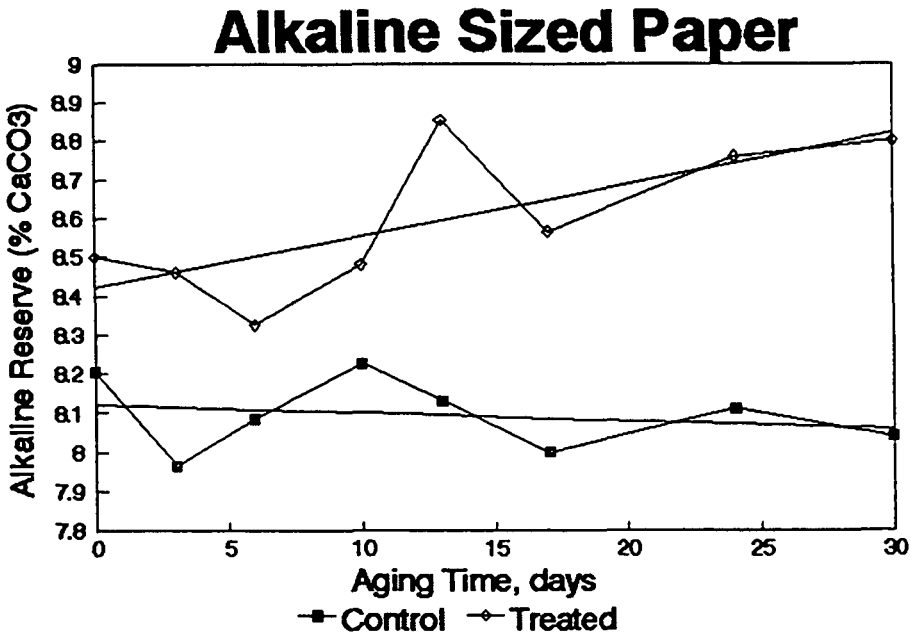

Fig.21-AS Affect of Aging Time on Alkaline Reserve (% CaCO3).

TABLE XXII

1% NaOH SOLUBILITY DATA (%)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	16.04	15.87	7.71	9.82	4.14	7.75	15.25	14.47
	Range	0.66	1.48	0.59	1.00	1.66	0.60	0.09	0.42
3	Average	17.07	16.60	10.67	8.93	7.36	7.79	15.76	15.87
	Range	0.83	0.12	0.92	0.10	0.08	0.10	0.31	0.20
6	Average	17.64	17.74	11.55	9.93	10.13	11.21	16.36	16.47
	Range	0.26	0.16	0.50	0.82	0.56	0.26	0.07	0.24
10	Average	19.40	18.98	11.68	12.33	12.03	9.78	15.80	15.61
	Range	0.32	0.21	0.29	0.03	2.84	1.13	0.76	0.29
13	Average	19.48	19.05	13.21	11.72	13.38	11.11	15.45	15.40
	Range	0.10	0.46	0.25	0.24	1.06	0.76	0.17	0.16
17	Average	19.28	18.20	14.27	11.30	12.21	9.88	15.71	15.98
	Range	0.05	0.39	0.33	0.13	1.16	1.72	0.14	0.03
24	Average	20.35	20.39	15.42	12.59	14.43	12.97	16.38	16.48
	Range	0.03	0.05	0.26	0.08	0.06	1.69	0.07	0.04
30	Average	21.20	20.45	17.05	13.33	17.19	15.39	16.60	16.41
	Range	0.31	0.15	0.48	0.04	1.40	0.26	0.14	0.10

REGRESSION STATISTICS

R Squared	0.892	0.840	0.936	0.766	0.860	0.811	0.451	0.391
Coefficient	0.158	0.146	0.274	0.130	0.368	0.223	0.031	0.041
Std Err	0.0224	0.0260	0.0292	0.0294	0.0606	0.0440	0.0141	0.0210
Constant	16.77	16.53	9.16	9.57	6.63	7.86	15.51	15.30

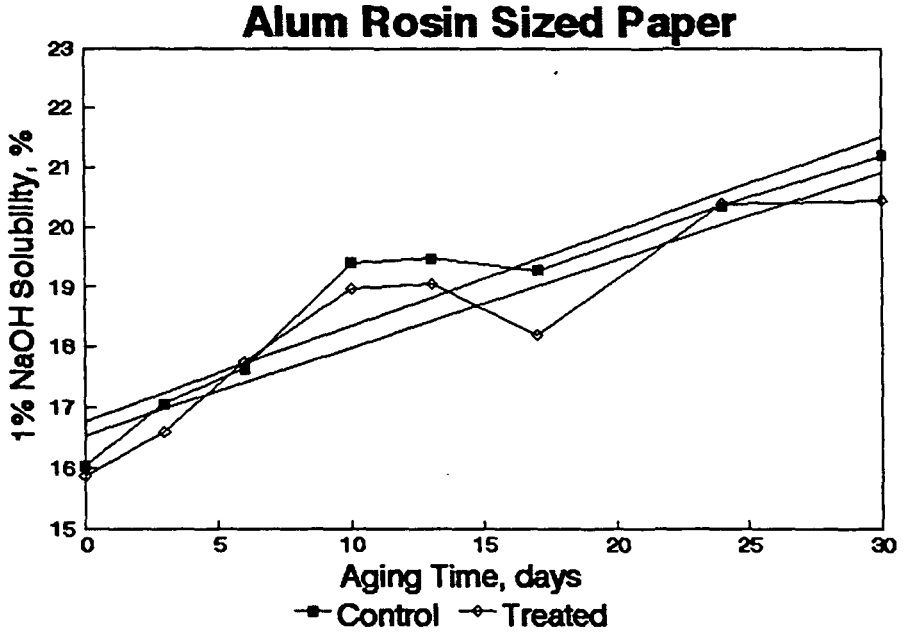

Fig.22-AR Affect of Aging Time on 1% NaOH Solubility.

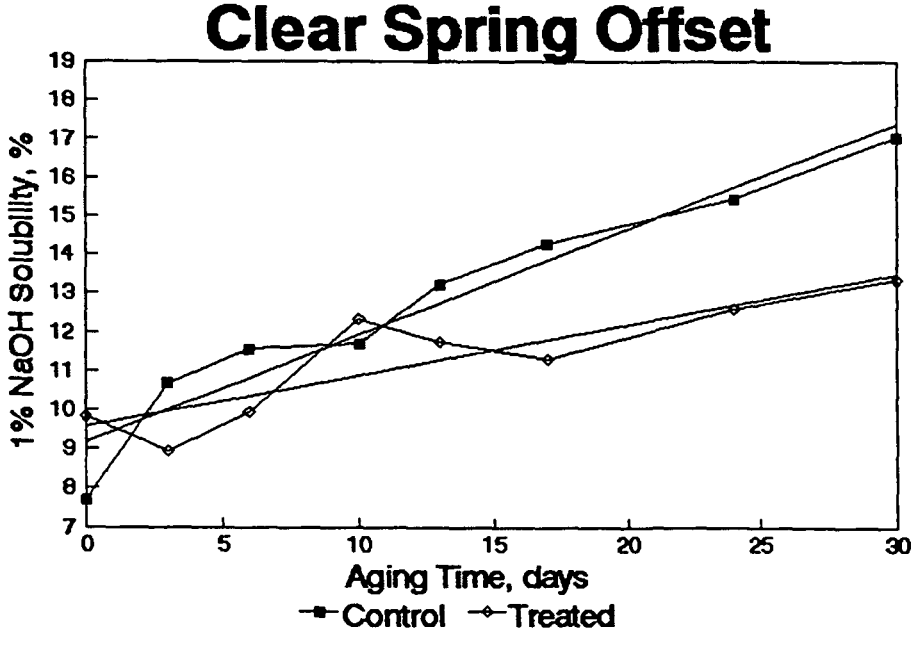

Fig.22-CS Affect of Aging Time on 1% NaOH Solubility.

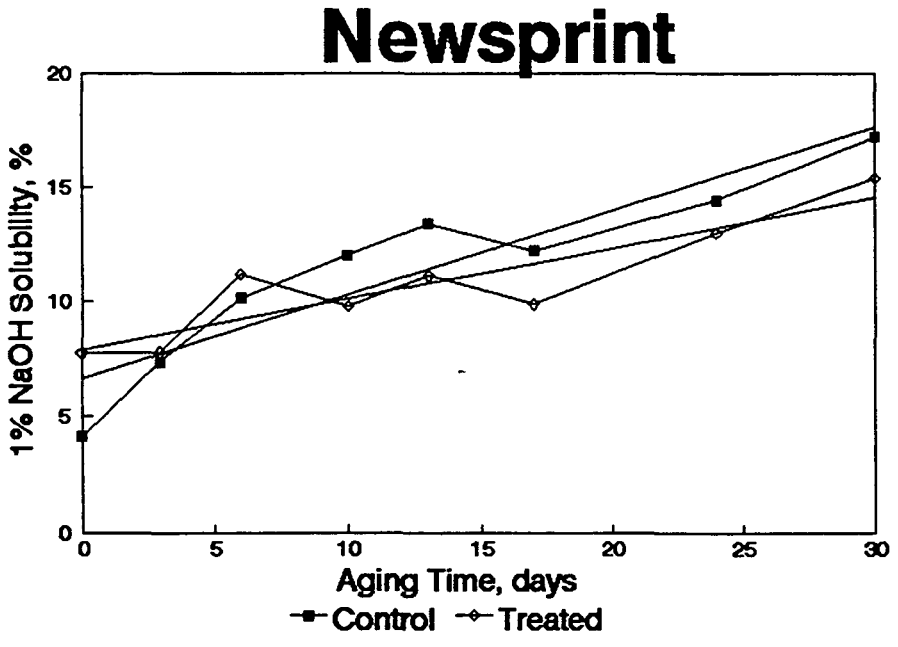

Fig.22-NP Affect of Aging Time on 1% NaOH Solubility.

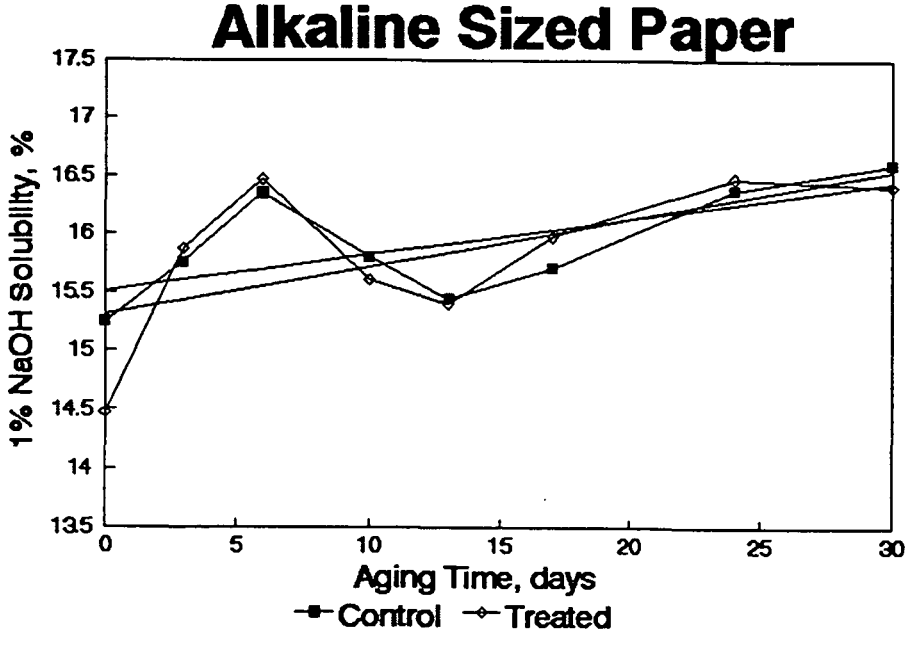

Fig.22-AS Affect of Aging Time on 1% NaOH Solubility.

TABLE XXIII

VISCOSITY DATA (mPa.s)

Aging Time, days	Test No.	ARC	ART	CSC	CST	NPC	NPT	ASC	AST
0	Average	5.74	5.57	13.46	11.74	4.56	4.16	6.94	6.16
	Range	0.12	0.21	0.07	0.21	0.47	0.10	0.05	0.10
3	Average	4.48	4.71	7.75	9.03	3.35	3.58	5.74	5.93
	Range	0.04	0.09	0.15	0.02	0.17	0.00	0.04	0.01
6	Average	4.07	4.43	6.33	7.86	2.79	3.12	5.79	6.34
	Range	0.10	0.02	0.08	0.02	0.02	0.02	0.07	0.04
10	Average	3.63	4.14	5.54	7.02	2.43	2.95	5.74	5.90
	Range	0.01	0.04	0.03	0.00	0.04	0.05	0.05	0.12
13	Average	3.41	3.80	4.72	6.23	2.64	2.43	5.71	5.44
	Range	0.03	0.02	0.07	0.12	0.01	0.00	0.12	0.02
17	Average	3.21	4.15	4.33	5.73	2.40	2.91	5.01	5.09
	Range	0.01	0.05	0.31	0.03	0.02	0.05	0.06	0.09
24	Average	2.98	3.43	3.93	4.71	2.21	2.45	5.31	4.92
	Range	0.02	0.01	0.02	0.13	0.01	0.02	0.02	0.09
30	Average	2.82	3.30	3.71	4.61	2.19	2.43	5.14	4.84
	Range	0.01	0.01	0.07	0.03	0.06	0.04	0.00	0.00

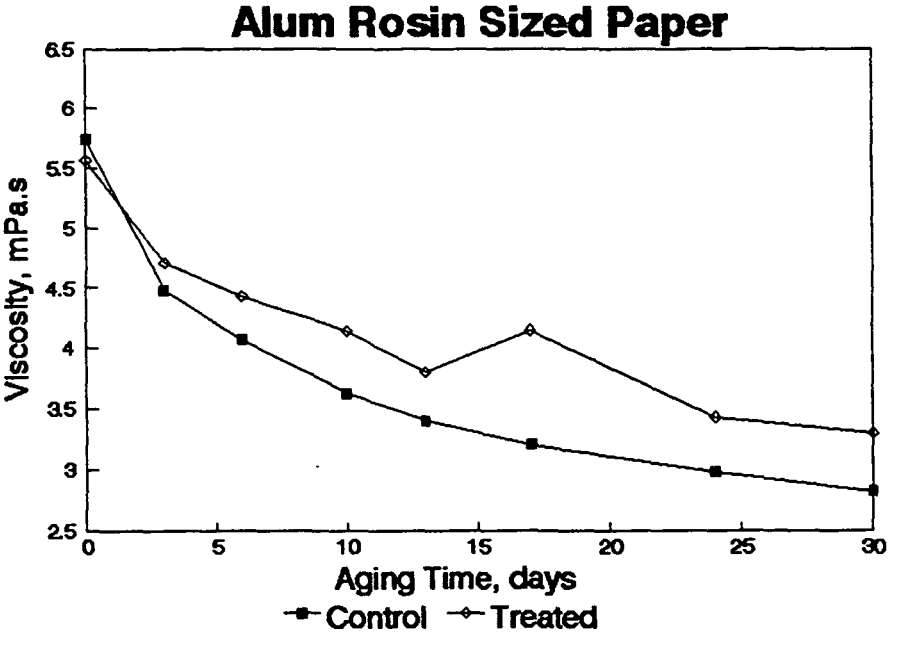

Fig.23-AR Affect of Aging Time on Viscosity.

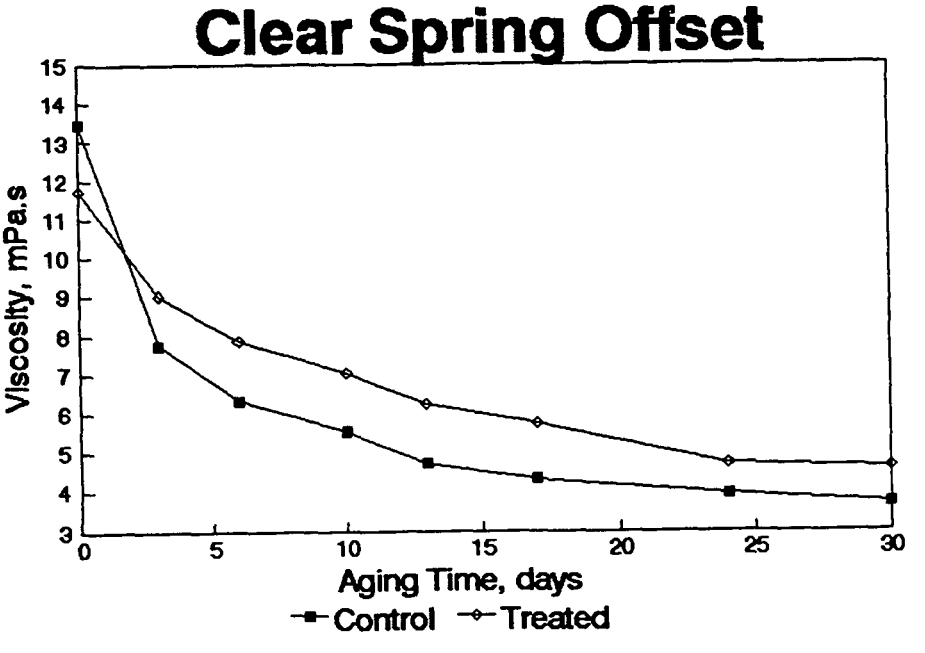

Fig.23-CS Affect of Aging Time on Viscosity.

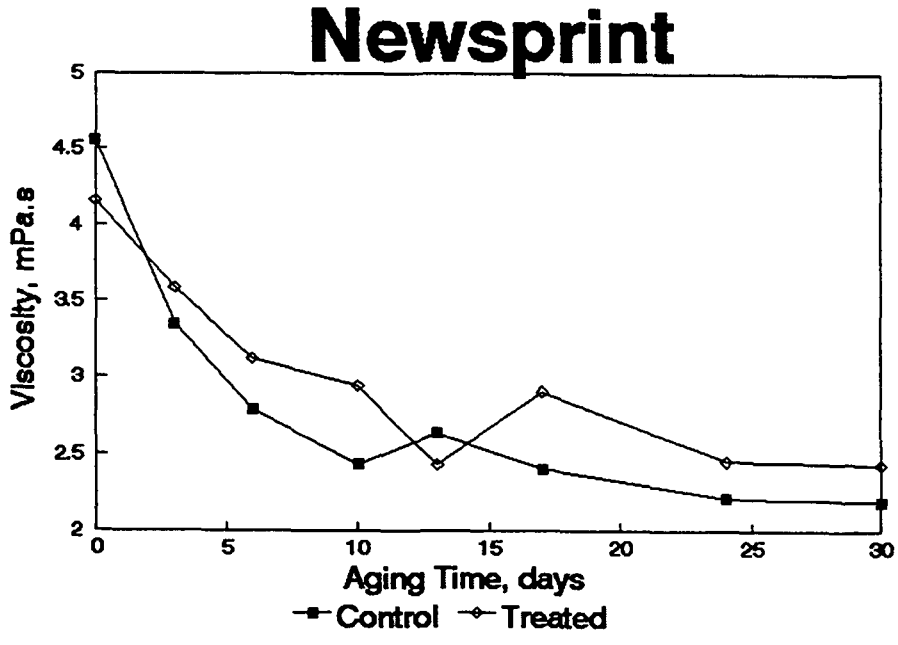

Fig.23-NP Affect of Aging Time on Viscosity.

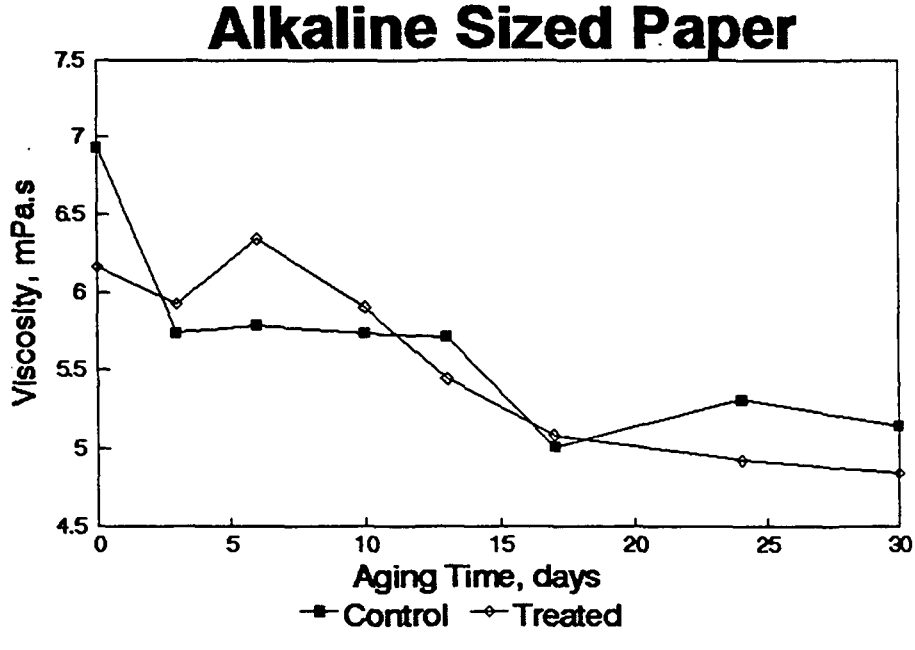

Fig.23-AS Affect of Aging Time on Viscosity.

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